NOV 3 1993

NAS 1.53:OSSA-1-91

NASA

National Aeronautics and
Space Administration

May 20, 1991
A.O. No. OSSA-1-91

Announcement of Opportunity

Facility Instrument Science Team for the Ion and Neutral Mass Spectrometer on the Cassini Saturn Orbiter

Notices of Intent due: June 10, 1991

Proposals due: August 23, 1991

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ANNOUNCEMENT OF OPPORTUNITY

FACILITY INSTRUMENT SCIENCE TEAM

FOR THE

ION AND NEUTRAL MASS SPECTROMETER

ON THE CASSINI SATURN ORBITER

AO NO. OSSA-1-91 May 20, 1991

I. INTRODUCTION

The National Aeronautics and Space Administration (NASA) announces the opportunity to propose Team Leader and Team Member investigations to use the Ion and Neutral Mass Spectrometer (INMS) facility instrument tentatively selected for flight on the Saturn Orbiter portion of the Cassini mission. A previous NASA Announcement of Opportunity (OSSA-1-89) solicited proposals for Principal Investigator/Instrument and Interdisciplinary Scientist investigations for the Saturn Orbiter; it also requested Team Leader and Team Member proposals for the four facility instruments then contemplated for inclusion in the payload. At the same time, the European Space Agency (ESA) issued a parallel Announcement of Opportunity (ESA AO SCI(89)2), requesting proposals for scientific investigations for the Huygens (Titan) Probe portion of the Cassini mission. Investigations selected for the Huygens Probe were announced by ESA in September 1990, and those tentatively selected for the Saturn Orbiter were announced by NASA in November 1990. The selected Saturn Orbiter payload includes the INMS as a fifth facility instrument; this AO requests proposals from scientists interested in conducting investigations as members of the INMS flight science team.

The Cassini mission is a joint undertaking by NASA and ESA to explore the Saturnian system with a Saturn Orbiter and a Titan Probe. The complexities and cost of this ambitious mission call for a joint effort by the scientific and technological communities of Europe and the United States (U.S.). The launch vehicle and the Saturn Orbiter will be the responsibility of NASA, while the Huygens Probe System (the detachable Titan probe plus the orbiter-mounted probe support subsystem) will be the responsibility of ESA. The two agencies will share responsibility for project management and mission operations. Scientific instruments for the Probe and Orbiter payloads will be supplied by the international community. The Cassini mission is well-suited to a division of effort between two partners, and offers rich benefits to both the European and U.S. scientific communities.

The primary goal of Cassini, which is part of the NASA Comet Rendezvous Asteroid Flyby (CRAF)/Cassini Program, is to conduct an indepth, second-phase exploration of the Saturnian system. It is planned that the Cassini spacecraft will be launched in late 1995 on a Titan IV/Centaur launch vehicle. Upon arrival at Saturn, the Saturn Orbiter will deliver the Probe to Titan and will then make repeated close flybys of Titan both for scientific study and for gravity-assisted orbit torquing. During its 4-year nominal mission the Saturn Orbiter will make detailed observations of the Saturnian atmosphere, magnetosphere, ring system, and a number of its icy satellites. In addition, during its cruise phase the spacecraft will make close flybys of Jupiter and at least one main-belt asteroid.

The Cassini mission is the first of the Mariner Mark II series of outer planet and primitive body missions recommended by NASA's Solar System Exploration Committee (SSEC) as an essential element of the solar system exploration core program. The second of this series is the CRAF mission, for which investigations were tentatively selected in October 1986. The Mariner Mark II spacecraft, now under development at the Jet Propulsion Laboratory, is modular in design, three-axis stabilized, and capable of cost-effective reconfiguration for each mission. In the Cassini configuration, instruments will be mounted to a scan platform for pointing, to a turntable for fields and particles measurements, or directly to the spacecraft. Detailed information on spacecraft capabilities and constraints (see Section V) will be provided in Volume IV of the Proposal Information Package, a set of documents which will be sent to all those responding to this AO with a Notice of Intent to propose for membership on the INMS Facility Instrument Team.

The goal of Cassini is to carry out a mission with high scientific return and wide scientific participation within a relatively modest, fixed cost envelope. The attainment of this goal will require a constrained selection of investigations, carefully planned sharing of spacecraft resources and capabilities, and sharing of reduced data sets. Final selection and confirmation of Cassini investigations, with the exception of those solicited by this AO, will take place at the conclusion of the Investigation Accommodation Phase, which began in November 1990. A Science Confirmation Review for both CRAF and Cassini, followed by final selection of investigations for both missions, is planned for early November 1991.

This AO is open to the international scientific community. In view of the NASA/ESA cooperation on Cassini, proposals from non-U.S. institutions are strongly encouraged, but only on a no-exchange-of-funds basis. Specific instructions for proposals from non-U.S. institutions are included in Section VI.

II. ANNOUNCEMENT OBJECTIVES

General scientific objectives for exploration of the outer planets, and of the Saturnian system in particular, have been established by the appropriate scientific advisory committees, including the Committee on Planetary and Lunar Exploration of the National Research Council's Space Science Board and the Solar System Exploration Committee of NASA. The concept of

Cassini as a combined Saturn Orbiter and Titan Probe mission, to be carried out as a joint NASA/ESA undertaking, was first proposed to ESA by a consortium of European scientists. Taking these earlier studies into account, specific objectives for the Cassini mission, including both the Saturn Orbiter and Titan Probe, were developed by the Cassini Joint Science Working Group with members from Europe and the United States. For additional information, see Volume II (Cassini Phase A Report, SCI(88)5) of the Proposal Information Package.

Proposals for INMS Facility Instrument Team Leader and Team Member investigations must address one or more of the following scientific objectives.

SCIENTIFIC OBJECTIVES

The Saturnian System: The Primary Target of Cassini

TITAN

- Determine abundances of atmospheric constituents (including any noble gases), establish isotope ratios for abundant elements, constrain scenarios of formation and evolution of Titan and its atmosphere.

- Observe vertical and horizontal distributions of trace gases, search for more complex organic molecules, investigate energy sources for atmospheric chemistry, model the photochemistry of the stratosphere, study formation and composition of aerosols.

- Measure winds and global temperatures; investigate cloud physics, general circulation, and seasonal effects in Titan's atmosphere; search for lightning discharges.

- Determine the physical state, topography, and composition of the surface; infer the internal structure of the satellite.

- Investigate the upper atmosphere, its ionization, and its role as a source of neutral and ionized material for the magnetosphere of Saturn.

SATURN

- Determine temperature field, cloud properties, and composition of the atmosphere of Saturn.

- Measure the global wind field, including wave and eddy components; observe synoptic cloud features and processes.

- Infer the internal structure and rotation of the deep atmosphere.
- Study the diurnal variations and magnetic control of the ionosphere of Saturn.
- Provide observational constraints (e.g., gas composition, isotope ratios, and heat flux) on scenarios for the formation and the evolution of Saturn.
- Investigate the sources and the morphology of Saturn lightning (Saturn Electrostatic Discharges (SED), lightning whistlers).

RINGS

- Study configuration of the rings and dynamical processes (gravitational, viscous, erosional, and electromagnetic) responsible for ring structure.
- Map composition and size distribution of ring material.
- Investigate interrelation of rings and satellites, including embedded satellites.
- Determine dust and meteoroid distribution both in the vicinity of the rings and in interplanetary space.
- Study interactions between the rings and Saturn's magnetosphere, ionosphere, and atmosphere.

ICY SATELLITES

- Determine the general characteristics and geological histories of the satellites.
- Define the mechanisms of crustal and surface modifications, both external and internal.
- Investigate the compositions and distributions of surface materials, particularly dark, organic rich materials and low melting point condensed volatiles.
- Constrain models of the satellites' bulk compositions and internal structures.
- Investigate interactions with the magnetosphere and ring systems and possible gas injections into the magnetosphere.

MAGNETOSPHERE OF SATURN

- Determine the configuration of the nearly axially symmetric magnetic field and its relation to the modulation of Saturn Kilometric Radiation (SKR).

- Determine current systems, composition, sources, and sinks of magnetosphere charged particles.

- Investigate wave-particle interactions and dynamics of the dayside magnetosphere and the magnetotail of Saturn and their interactions with the solar wind, the satellites, and the rings.

- Study the effect of Titan's interaction with the solar wind and magnetospheric plasma.

- Investigate interactions of Titan's atmosphere and exosphere with the surrounding plasma.

Targets of Opportunity

ASTEROID FLYBY

- Investigate an asteroid not seen by previous missions, possibly a new class of asteroid, thereby adding important new information to the study of asteroids.

- Characterize global properties, determine composition and morphology of the surface, investigate properties of the regolith.

JUPITER FLYBY

- Extend the time for studies of atmospheric dynamics and variable satellite phenomena, specifically Io volcanism, beyond the period accessible to the Galileo nominal mission.

- Infer global atmospheric thermal structure and composition with instrumentation not carried by the Galileo Orbiter, complementing the local *in situ* measurements of the Galileo Probe.

- Explore the dusk side of the magnetosphere and intermediate regions of the magnetotail unvisited by previous spacecraft.

- Obtain the first high-resolution images of the Io torus.

CRUISE SCIENCE

- Extend the sensitivity of composition measurements of interstellar ions by approximately three orders of magnitude.
- Investigate the behavior of the solar wind during solar minimum, for comparison with earlier Galileo and Ulysses measurements.
- Extend spacecraft searches for gravitational waves.
- Extend studies of interplanetary dust to the orbit of Saturn.
- Attempt to detect internal oscillations of Saturn, Jupiter, and some stars.

Investigations addressing other scientific objectives which take advantage of the unique characteristics of the Cassini mission will also be considered, but at lower priority.

III. DESCRIPTION OF THE OPPORTUNITY

A. TYPES OF PROPOSALS

This Announcement solicits proposals from individual scientists wishing to participate in the Cassini mission through membership on the Ion and Neutral Mass Spectrometer Facility Instrument Team. The INMS has been tentatively selected for flight on the Saturn Orbiter, and is subject to confirmation and final selection in November 1991.

Background information and a brief description of the INMS facility instrument is given in Section V.C.2, while more detailed information is contained in Volume XIV of the Proposal Information Package.

Individuals may propose to be the Team Leader (TL) or a Team Member (TM) on the NASA-formed team to use the INMS facility instrument for scientific investigations. Individuals proposing to be Team Leader will also be considered for Team Member in the event they are not selected as Team Leader; if they do not wish to be so considered, they should so state in their proposals. Proposers should indicate the specific skills and capabilities that they will bring to the Facility Instrument Team and why they should be involved with the facility instrument from development activities through data analysis. They must propose to carry out a scientific investigation with data from the INMS facility instrument leading to publication of results. In addition, they should propose to participate in such activities as science planning, final instrument definition, operations, data management, data analysis, calibration, and algorithm development. Proposals may also describe synergistic investigations which utilize data from other Saturn Orbiter instruments, or from Huygens Probe instruments, along with INMS results. In preparing

their proposals, prospective Team Leaders or Team Members should note the following conditions (which are discussed in more detail in Sections V.C.2 and VI.B):

(a) The final decision regarding inclusion of the INMS facility instrument in the Saturn Orbiter payload will be made by NASA after the review of proposals received in response to this AO and the completion of the Science Confirmation Review in November 1991.

(b) Proposals for Team Leader or Team Member must be submitted by individuals. Proposals from teams or groups of investigators will not be considered. However, individual proposers may include the participation of a limited number of appropriate support personnel in their proposal.

B. SCHEDULE

It is requested that a written Notice of Intent, signifying the writer's intent to propose in response to this AO, be submitted to NASA Headquarters on or before June 10, 1991. Details are given in Section VI.A. A Notice of Intent is not required, but is requested as an aid in planning the proposal evaluation process.

Individuals who submit Notices of Intent will be sent a Proposal Information Package consisting of documents that provide details about the CRAF/Cassini Project and spacecraft, the Saturn Orbiter mission, descriptions of the selected Saturn Orbiter and Huygens Probe instruments, and other information needed to prepare the proposal. Details of the contents of this package are given in Section VI.A.

No preproposal briefing will be held.

Proposals must be received at the NASA Headquarters address(es) given in Section VI.A.1 on or before 4:30 p.m. (EDT) August 23, 1991.

Selection of the INMS Facility Instrument Team is planned to occur during November 1991.

C. CASSINI PROJECT SCIENCE GROUP

After tentative selection of the investigations in November 1990, a Cassini Project Science Group (PSG) was established. All Saturn Orbiter and Huygens Probe Principal Investigators, all Team Leaders of Orbiter facility instruments, and all Interdisciplinary Scientists automatically became members of the Cassini PSG, including those selected through both the NASA and ESA processes. The INMS Facility Instrument Team Leader, to be selected on the basis of this AO, will also become a member of the Cassini PSG. The Cassini PSG is chaired by the Cassini Project Scientist. The PSG will meet regularly throughout the lifetime of the mission and will work with the Cassini and Huygens Project Scientists, the CRAF/Cassini Program Scientist, and

the CRAF/Cassini and Huygens Project Managers to optimize mission science return and to resolve conflicts among requirements. Responsibilities of the Cassini PSG members are described in detail in Volumes XI and XII of the Proposal Information Package.

D. SUBSEQUENT ANNOUNCEMENTS

One or more additional opportunities to participate in the Cassini mission as a Participating Scientist (PS) will be announced later. The release of these announcements will be timed to permit selection of PS investigations for appropriate planning and data-gathering periods. These opportunities will also serve to encourage coordination among the Cassini, CRAF, and Galileo missions, thereby enhancing the science return from all three. The Cassini and CRAF asteroid flybys occur in November 1998 and February 1999, respectively, suggesting a joint PS opportunity. The Cassini flyby of Jupiter occurs in April 2000, suggesting a PS program to relate flyby results to Galileo data gathered during the 1996-97 nominal mission and any extended Galileo mission. NASA also plans to establish an Outer Planets Data Analysis Program, open to the international community, commencing with the first public availability of Galileo data in 1996 and continuing at least through the Cassini Jupiter flyby in 2000.

IV. MISSION BACKGROUND

The Cassini mission will explore the Saturnian system, which contains a host of volatile-rich bodies and a record of the processes that have modified them. Remote measurements of the composition of Saturn's atmosphere will provide information about the original elemental and isotopic composition of the solar nebula. Images of the surfaces of the icy satellites of Saturn will reveal a record of early solar system accretionary, heating, and cratering processes. Long-term remote observations of the rings will provide data about collisional, gravitational, and plasma processes that were important in the early stages of planet formation. Measurements of the surface and atmospheric composition of Titan will yield information on prebiotic chemical processes in planetary atmospheres, some of which resemble processes that may have operated in Earth's primitive atmosphere. Observations of Saturn's magnetosphere, and of Titan's interaction with it, will provide information on plasma processes that have application to many astrophysical settings. The Cassini mission thus promises to provide a wealth of new data vital to furthering the current understanding of chemical and physical processes involved in the formation and evolution of the solar system.

In its 1975 report on space science, the Space Science Board of the National Research Council and its Committee on Planetary and Lunar Exploration (COMPLEX) recognized that "the outer planets and their satellites represent a wholly new class of planetological problems, which are fundamental to the understanding of the formation of the solar system and about which we have little information." COMPLEX recommended that an indepth exploration of Jupiter and its satellites be achieved by 1985 (Galileo) and that, further, NASA position itself to undertake a detailed exploration of the Saturnian system subsequent to the Pioneer and Voyager

reconnaissance missions. These objectives, together with those formulated by COMPLEX for the investigation of the terrestrial planets and the primitive bodies, have provided the scientific basis for development of an implementation strategy for NASA's solar system exploration program.

In order to address the implementation of these recommendations, the NASA Advisory Council in 1980 formed the Solar System Exploration Committee (SSEC) to develop a mission strategy for the planetary program through the end of the century. The 1983 report of the SSEC recommended a new generation of scientifically vital, yet affordable, solar system exploration missions that would be consistent with the scientific recommendations of COMPLEX while taking advantage of spacecraft hardware inheritance, development of a multimission operations system, and other cost-saving measures.

The SSEC report recommended an initial sequence of four core missions. The first of these, the Venus Radar Mapper (now Magellan) is on its way to Venus. The second, the Mars Observer, is under development. CRAF, the third mission, has a tentatively selected payload and will be the first mission to use the Mariner Mark II spacecraft. The Cassini mission results from combining the fourth SSEC recommended initial core mission (Titan Probe/Radar Mapper) with the committee's highest priority outer planet mission (Saturn Orbiter) in the subsequent core mission group. This combined mission, and the name Cassini, were first proposed to ESA by a consortium of European scientists in 1982; the proposers suggested at that time that the mission be carried out in collaboration with NASA. In that same year, the Space Science Committee of the European Science Foundation and the Space Science Board of the U.S. National Academy of Sciences set up a Joint Working Group (JWG) to study possible cooperation between Europe and the United States in the area of planetary exploration. In its 1986 report, one of the potential cooperative missions recommended by the JWG was a Saturn Orbiter and Titan Probe mission.

In 1986 COMPLEX updated its strategy for outer planets exploration. Based on the assumptions that by 1990 Voyager will have completed flybys of all the giant planets, and that the Galileo probe and orbiter will have been launched to Jupiter, the Committee wrote that "the highest priority for outer planet exploration in the next decade is intensive study of Saturn — the planet, satellites, rings, and magnetosphere — as a system."

During 1986, the prospects for timely NASA/ESA cooperation on Cassini materialized: NASA announced the initiation of a Cassini Phase-A study, and later that year ESA's Science Programme Committee (SPC) approved a Phase-A study for the Cassini Titan Probe. In 1987 and 1988, NASA carried out further definition work on the Mariner Mark II spacecraft and on the first two missions designed to use it, CRAF and Cassini. The Cassini Joint Science Working Group (JSWG), with membership appointed by NASA and ESA, supported these studies. The report of the Cassini JSWG, along with an addendum including some later work, will be provided as Volume II of the Proposal Information Package.

In early 1988, NASA combined CRAF and Cassini into a single (CRAF/Cassini) program and later that year requested new start approval. ESA approved its contribution to Cassini in

November 1988, and named its contribution to the program the Huygens Probe. The CRAF/Cassini program received congressional approval for a new start in Fiscal Year 1990.

Coordinated Announcements of Opportunity for the Saturn Orbiter and the Huygens Probe were issued by NASA and ESA, respectively, in October 1989. Investigations selected for the Huygens Probe were announced by ESA in September 1990, and those tentatively selected for the Saturn Orbiter were announced by NASA in November 1990. Following a 1-year Investigation Accommodation Phase, confirmation and final selection of the Saturn Orbiter investigations will occur in November 1991.

V. REQUIREMENTS AND CONSTRAINTS

A. BASELINE MISSION DESCRIPTION

The Cassini spacecraft (Orbiter/Probe) will be launched on a Titan IV/Centaur launch vehicle in November/December 1995. The trajectory will include a gravity-assist flyby of Venus in December 1996 followed by a flyby of Earth in July 1998, and a subsequent flyby of Jupiter in April 2000. In addition, a close flyby of a main belt asteroid will be conducted during interplanetary cruise; the current target is Clarissa, with the flyby occurring about three years after launch. This sequence of events will result in arrival at Saturn in May 2004. Volume III, Mission Description, of the Proposal Information Package presents detailed information on an earlier version of the baseline Cassini mission. Note that the mission design has evolved since Volume III was originally published. For any differences between mission features described in this AO and those in Volume III, the AO takes precedence.

The Saturn orbit insertion maneuver will occur near periapsis at about 1.3 Saturn radii (R_S), and will place the spacecraft in a highly elliptical orbit with a period of about 130 days. Near apoapsis of this orbit another maneuver will raise periapsis to about 9 R_S, and will place the spacecraft on a Titan impact trajectory. About 22 days before Titan encounter, the Probe will be properly oriented for Titan entry, and then spun up and separated from the Orbiter. Approximately two days later, the Orbiter will perform a deflection maneuver to establish the proper flyby geometry for both the Probe data relay and the start of the orbital tour of the Saturn system.

Huygens Probe entry will occur in September 2004. All of the Probe mission data will be transmitted to the Saturn Orbiter, which will be executing a flyby of Titan with a closest approach altitude of 1500 km. The Orbiter will immediately relay the data to Earth and will simultaneously record the data for later playback.

Following the Huygens Probe mission, the Orbiter will continue on a tour of the Saturnian system. The tour duration will be four years, from Saturn orbit insertion to the end of the nominal mission. This will allow approximately 60 Saturn orbits, the size and orientation of

which will be controlled by Titan gravity-assist flybys. There will be approximately 35 Titan flybys during the 4-year tour, providing many opportunities for Titan science acquisition.

There will be many nontargeted encounters with Saturn's icy satellites during the tour; in addition, Titan gravity assist will be used to target the spacecraft for close flybys of some of these satellites. Both equatorial and inclined orbits will allow extensive coverage of Saturn's atmosphere and magnetosphere. Inclined orbits will also allow high-resolution imaging of Saturn's rings, as well as creating periods of Saturn and ring occultations. The nominal mission will end in May 2008 with the spacecraft in a near-polar Saturn orbit. An extended mission, including additional Titan flybys, may be possible if sufficient navigation and attitude control propellants are available.

1. Interplanetary Trajectory. The heliocentric spacecraft trajectory for a November/December 1995 launch to Saturn is illustrated in Figure 1. The first propulsive maneuver will be executed five months after launch, followed eight months later by a Venus flyby that will place the spacecraft on an Earth return trajectory. The altitudes of the Venus and Earth flybys will be 300 km. A second maneuver will be performed about 5 days after the Earth flyby, and a third maneuver will take place 5 days after the Clarissa flyby. Jupiter will provide the final gravity assist that will enable the spacecraft to travel on to Saturn.

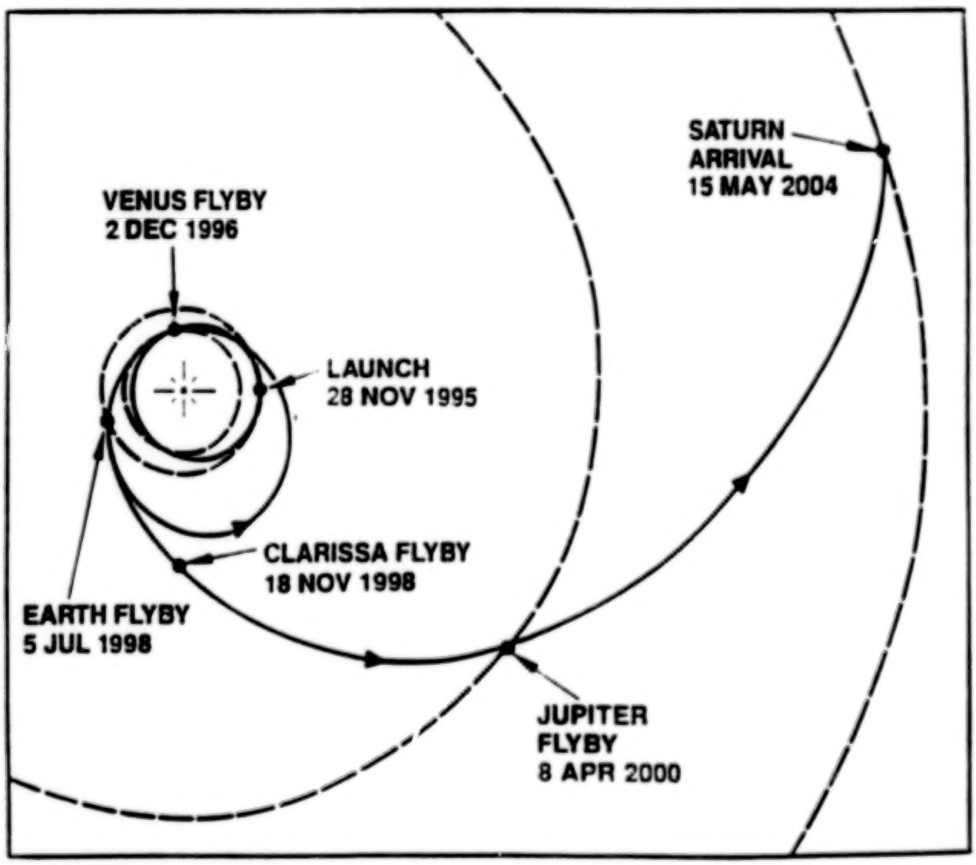


Figure 1. Cassini 1995 Baseline Trajectory

2. Asteroid Flyby. The spacecraft trajectory will enter the asteroid belt only once. A survey was made of the asteroids that pass close to the trajectory to determine if a flyby of a specific asteroid could be incorporated into the baseline mission design. The result of this study is the inclusion of a flyby of the F-type asteroid Clarissa (radius 20 km) on November 18, 1998 (see Figure 2).

The Clarissa flyby distance will be selected based on the science objectives and on spacecraft safety considerations, and is presently set at 80 asteroid radii, or about 1600 km. The inclusion of an asteroid flyby has a significant effect on the mission design, and implies some tradeoff among asteroid science and the other science objectives. Future considerations may involve reassessment of the asteroid selection or possible inclusion of a second flyby target. Details of the flyby strategy will be developed by the Cassini PSG and the CRAF/Cassini Project.

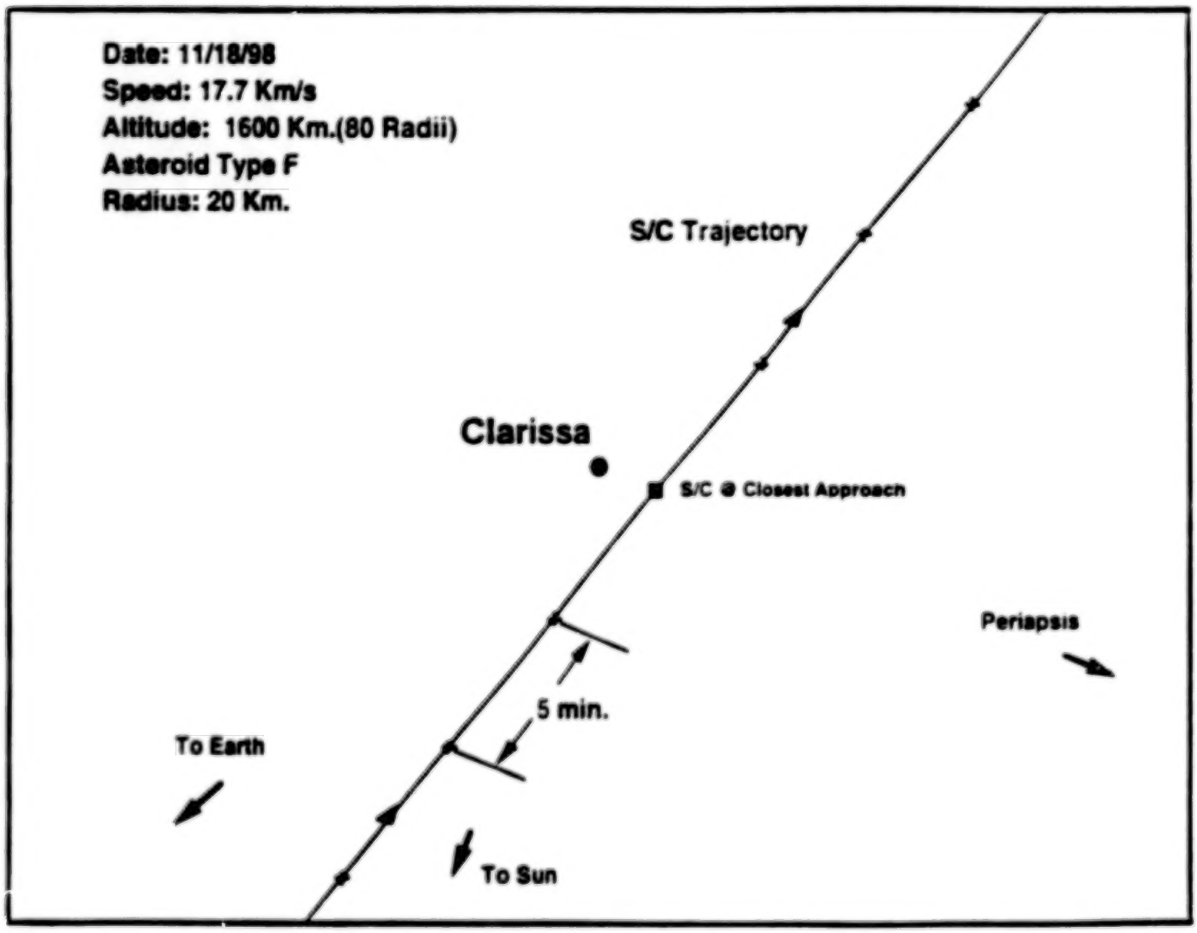


Figure 2. Baseline Mission Flyby of Asteroid Clarissa

3. Jupiter Flyby. Closest approach to Jupiter will occur in early April 2000, at a distance of about 52 Jovian radii (R_J). The radiation environment poses no threat at this distance. The mission performance is very sensitive to the Jupiter aimpoint, so there is no possibility of perturbing the trajectory for a flyby of a Galilean satellite. In addition, there does not appear to be an opportunity to encounter any of the outer Jovian satellites. However, significant Jupiter flyby science should be achievable. For example, as Figure 3 shows, the spacecraft will spend about 118 days in the magnetotail, out to a distance of over 1100 R_J. This is a much greater distance than that covered by either the Galileo or Voyager spacecraft, and will allow the magnetotail to be mapped more completely. Other remote sensing science may be conducted during the flyby to complement measurements made during the Galileo mission.

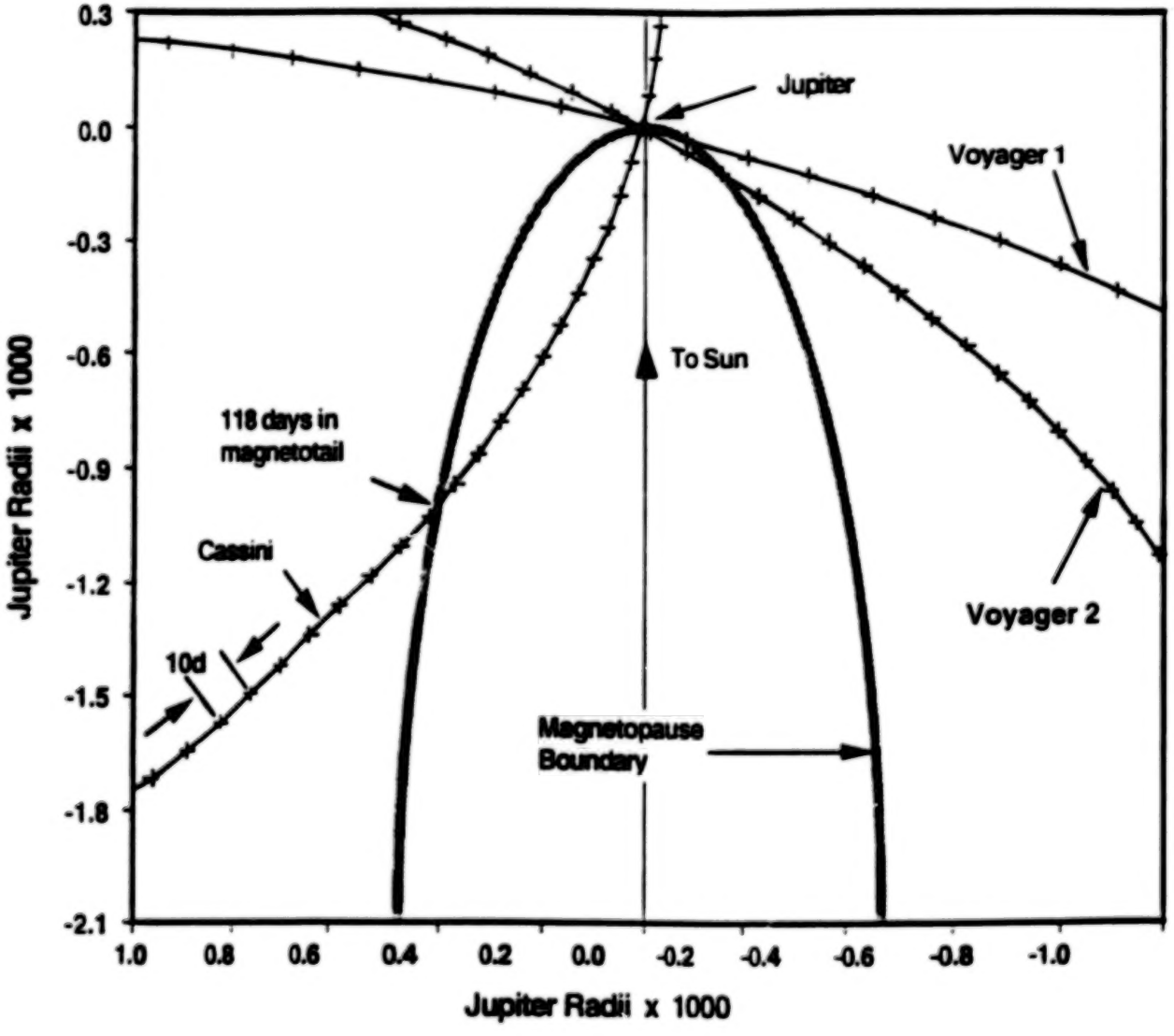


Figure 3. Jupiter Magnetotail Passages

4. Saturn Orbit Insertion (SOI) and Probe Delivery. Upon arrival, the spacecraft will be inserted into an initial highly eccentric orbit with a period of 130 days and a periapsis radius of 1.3 R_S (see Figure 4). The initial orbit is inclined about 25° with respect to Saturn's equator. The SOI burn may be delayed to allow a brief period for limited science acquisition in the region of 1.3 R_S, possibly including fixed scan platform imaging and fields and particles science. This possibility will be implemented only if the added risk to the mission is determined to be minimal. The decision on near-SOI science will be made by the Cassini PSG and the CRAF/Cassini Project.

At apoapsis of the initial orbit (about 65 days after SOI) a maneuver will be performed to raise the orbit periapsis from 1.3 R_S to about 9 R_S, and to target the spacecraft to Titan. Final targeting maneuvers will be performed to adjust the Probe aim point, and the Probe will be released from the Orbiter about 22 days before Titan encounter. About 2 days after Probe separation, the Orbiter will perform a deflection maneuver to establish the proper Titan flyby conditions for Probe data relay and the start of the orbital tour.

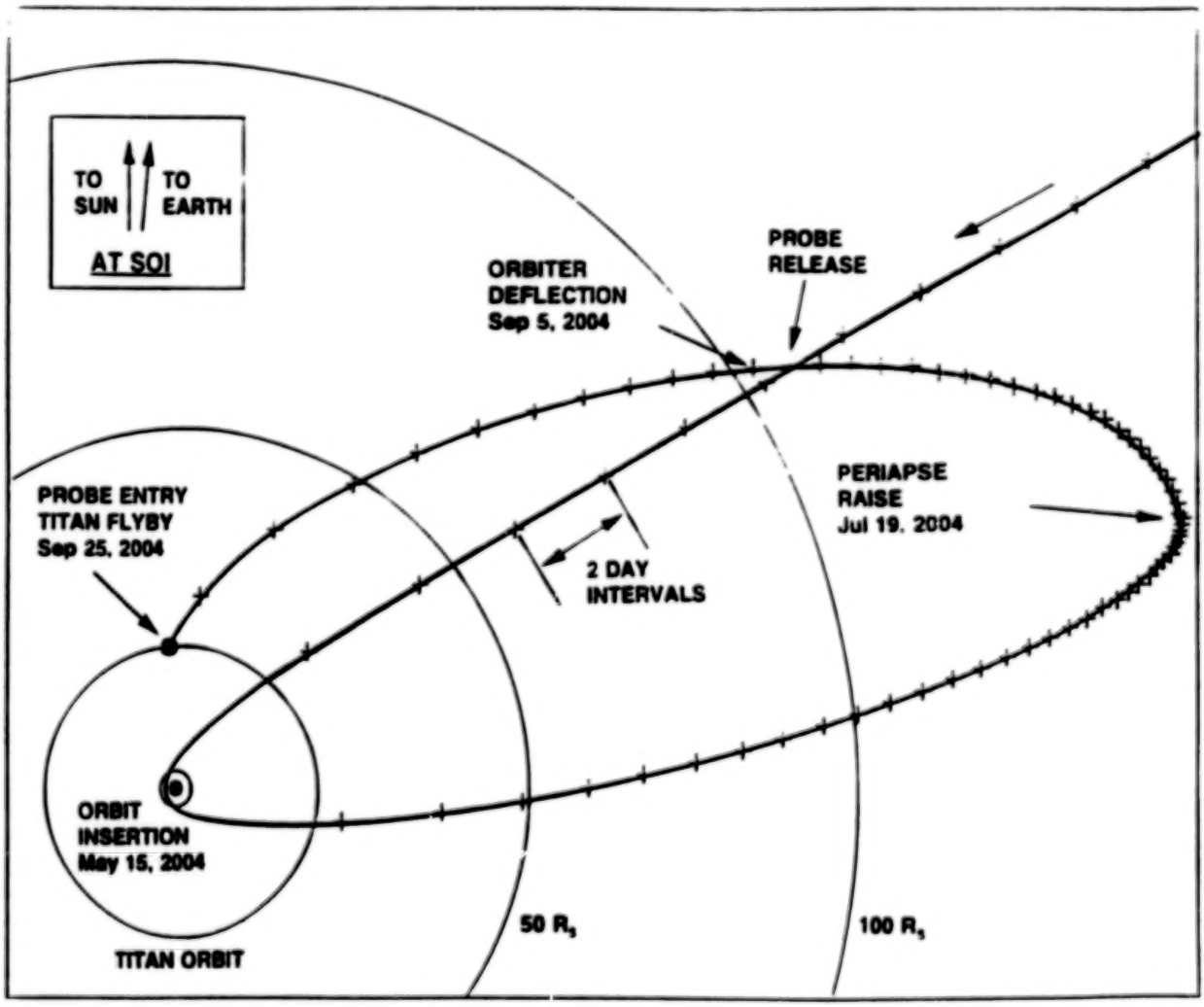


Figure 4. Cassini 1995 Baseline Trajectory - Initial Saturn Orbit

5. Orbiter Mission. The Cassini orbital tour will begin immediately upon completion of the Probe mission, and will last until 4 years after SOI. It will consist of about 60 orbits of Saturn, each with an average period of approximately 32 days for the first 3 years. The precise dimensions and orientations of these orbits will be dictated by the various science requirements, and will be achieved by Titan gravity-assist flybys and/or small propulsive maneuvers. The reliance on flybys of Titan for gravity assist means, effectively, that the Saturn Orbiter part of the Cassini mission has two primary targets, Saturn and Titan. During the course of the 4-year tour of the Saturnian system there will be opportunities for detailed study of both of these bodies, as well as the icy satellites, the rings, the magnetosphere, and their mutual interactions.

The nominal orbital tour will end with the spacecraft in a high-inclination orbit with a period of about 7.1 days. From a trajectory design standpoint, there could be many opportunities for additional Titan flybys after the end of the nominal tour.

Figure 5 shows selected orbits from the current baseline Cassini tour, designated 89-01. This is the baseline orbital tour for planning purposes only; the detailed strategy and tour design for the actual mission will be developed during the mission definition phase by the Cassini PSG and the CRAF/Cassini Project. In addition, further analysis of the hazard to the spacecraft posed by Saturn ring particles may indicate the need for additional constraints on the orbital tour. This is discussed further in Section V.A.5.e.

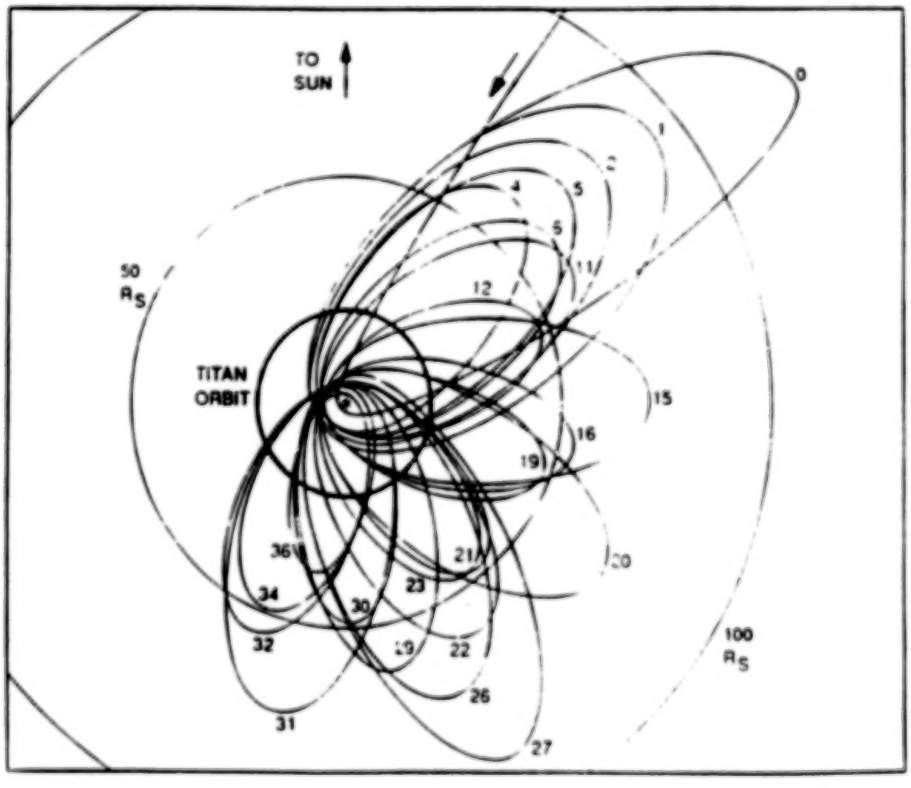


Figure 5. Representative Saturn Tour (89-01)

a. Titan Flybys. The baseline strategy calls for an initial Titan flyby that occurs at a low altitude (about 1500 km) and that simultaneously reduces the spacecraft's orbital period and inclination. The initial Titan flyby must satisfy the requirements of the Probe's radio relay link geometry, while efficiently initiating the Orbiter's tour.

The 35 Titan flybys during the baseline orbital tour have a velocity of about 6 km/s at closest approach to Titan. Seven of these flybys will pass behind Titan as seen from Earth, resulting in Titan occultations of about 10-18 minutes duration. In the present tour design, these occultations occur fortuitously; no attempt has been made to optimize the flyby geometry to increase the number of occultations. Of the 35 Titan flybys, 32 occur at altitudes of 8000 km or less, and thus would be useful for the radar instrument. The lowest expected altitude for these flybys is 950 km. It should be noted that the Orbiter High Gain Antenna (HGA) is used for the radar function, which requires that it be pointed at Titan (rather than Earth) for the Titan Radar Mapper science passes.

While the Titan flyby geometry must be chosen primarily to produce the desired effect on the Saturn-centered orbit, future tour planning will also consider ways in which Titan flyby science can be optimized. There will be some tradeoffs required as a Titan flyby is perturbed away from the optimum gravity assist parameters to a geometry that maximizes flyby science. Spacecraft safety considerations related to Titan's upper atmosphere must also be taken into account.

Figure 6 shows a representative trace of the spacecraft ground tracks on a map of Titan for close flybys with a periapsis altitude of less than 8000 km. These ground tracks do not show the actual widths or locations of the radar swaths, but indicate the approximate distribution of coverage.

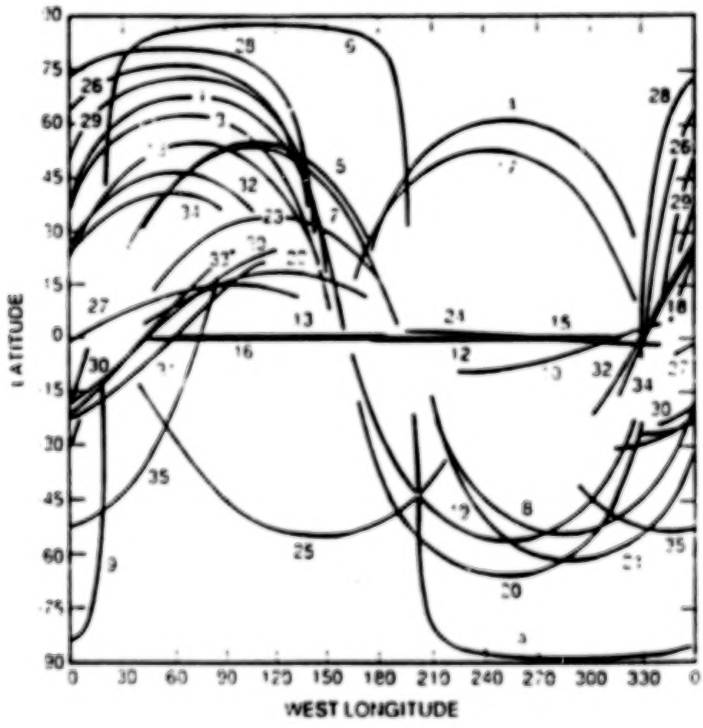


Figure 6. Ground Tracks of Titan Flybys (Altitudes Below 8000 km) During a Representative Saturn System Tour (89-01)

b. Icy Satellite Flybys. The baseline tour includes two targeted close flybys of Iapetus and one each of Enceladus and Dione, at altitudes of about 1000 km or less. Inclusion of close icy satellite flybys generally requires a significant expenditure of propellant, so the number of these flybys must be limited. There are also a total of 39 nontargeted satellite encounters at distances less than 100,000 km during the baseline mission. All major Saturnian satellites are included in this set with the exception of Phoebe, for which a flyby is not possible with these trajectories. The velocities of the satellite flybys range from about 3 km/s for the targeted Iapetus flybys to over 20 km/s for flybys of Mimas and Enceladus near the end of the tour.

c. Saturn and Ring Occultations. There are 4 equatorial and 18 high-inclination passes behind the disk of Saturn, and 5 additional passes behind the rings during the current baseline tour. These result in both Sun and Earth occultations. No attempt has yet been made to find useful stellar occultations during the tour, though they undoubtedly exist. Saturn occultations will not generally occur fortuitously during the tour as do the Titan occultations, so any requirement for Saturn occultations would have a significant effect on tour design.

d. High Inclination Orbits. The science requirements for investigation of the Saturn polar and Saturn Kilometric Radiation (SKR) regions mean that the spacecraft must achieve an orbit with an inclination (with respect to Saturn's equator) of about 80° during the tour. Such high inclinations can be achieved using Titan gravity assists, but only if the orbital period is gradually decreased as the inclination is increased. An inclination of 80° can be reached if the spacecraft orbital period is reduced to about 7.1 days.

e. Ring Plane Crossings. There will be many crossings of Saturn's outer rings during the tour; these may provide useful science opportunities for dust and plasma experiments. Two crossings in the F-G ring gap at about 2.6 R_S will occur immediately before and after SOI, and crossings of this type occur again near the end of the tour. The majority of the crossings will be in the E-ring between about 4 and 7 R_S. It is possible that the spacecraft orientation will be constrained during ring plane crossings to minimize the possibility of damage due to particle impacts.

The baseline tour includes a number of near-equatorial Saturn orbits; for these very low-inclination orbits, the spacecraft will spend a significant amount of time traversing the E-ring, from its edge at about 9 R_S to orbit periapsis at 3-5 R_S, and back out again. These orbits will cross the orbits of the major E-ring satellites; recent modeling suggests that increased populations of potentially hazardous particles may exist near these orbits. If the presence of these hazards is confirmed, the near-equatorial orbits may have to be modified to avoid them. This would reduce the number of icy satellite encounters during the tour, and may result in the loss of several Titan flybys. In addition, coverage of the inner magnetosphere would be affected, as would the ability to reach the desired 80-degree inclination by the end of the tour.

Further details regarding this issue can be found in Volume III of the Proposal Information Package.

6. End of Mission. For purposes of this AO, the nominal mission will end in May 2008, four years after SOI. Depending on the remaining propellant and the condition of the spacecraft, an extended mission phase could be considered. If an extended mission phase is undertaken, it is NASA's intent to issue an open announcement inviting proposals from all who might wish to participate; new proposals will be required from investigators participating in the primary mission who wish to continue their previously selected investigations into the extended mission phase.

B. SPACECRAFT CAPABILITIES AND CONSTRAINTS

The Saturn Orbiter to be used for the Cassini mission will be the first spacecraft of the Mariner Mark II (MM II) series. The MM II spacecraft is specifically designed for high-quality science return from cometary, asteroidal, and planetary missions beyond the orbit of Mars. The combination of inheritance, common spacecraft modular components, and new technologies applied to spacecraft parts reduces overall mission costs. The spacecraft is designed to operate from 0.61 AU to 10 AU from the Sun, with a design life of 13 years plus ground test.

Use of the MM II spacecraft imposes specific constraints on the mass, volume, power, and data return capabilities available to the science instrument payload. These capabilities and constraints are described in Volume IV, Spacecraft Description, of the Proposal Information Package. Note that the spacecraft design has evolved since Volume IV was originally published. For any differences between the capabilities described in this AO and those in Volume IV, the AO takes precedence. Current design studies indicate that available resources for the Saturn Orbiter science payload will be:

Mass: 244 kg

Power: 209 watts at Saturn arrival (post SOI)
199 watts at End of Mission

Data: On-board storage consists of 2 Solid State Recorders (SSR's), each with 1.8×10^9 bits storage and a bit error rate of 5×10^{-6}. Project policy requires the nominal mission to use only one recorder through the first 2 years of encounter. Enhanced spacecraft operation will allow recording on one recorder while playing back the other to the downlink. Total spacecraft telemetry is limited to 518 kbps (record + downlink, including playback). Maximum telemetry rate for any one instrument is between 400 kbps and 159 kbps, depending on the other instruments in use at a particular time.

Deep Space Network (DSN) coverage during the orbital tour will normally consist of continuous 34-meter station passes per day with two 34-meter stations arraying for the high-activity periods of each orbit (e.g., about 12 days out of each 32-day orbit), and one 34-meter station pass per day for the remainder of each orbit. Downlink data rates will vary between 12 and 123 kbps (average of 3000 megabits (Mb) data returned per day during high-activity periods) when the spacecraft is 8-10 AU from Earth, depending on the particular DSN 34-meter station being used and whether arraying is allowed.

The other features of the MM II Saturn Orbiter spacecraft are described below.

The MM II spacecraft will be three-axis stabilized, using a High Precision Scan Platform (HPSP)-mounted inertial reference unit and an Imaging Science Subsystem Wide Angle Camera functioning as a star tracker; a Sun sensor; a reaction wheel assembly; and thrusters. Instruments requiring fine pointing control will be located on the HPSP. Specifications for the allowable volume and inertia on the HPSP are included in Volume IV of the Proposal Information Package.

The Huygens Probe will be mounted on and deployed from the Orbiter spacecraft near the end of the initial Saturn orbit. The ESA-provided Probe Support Equipment will be installed on the Orbiter spacecraft and will consist of the Probe relay antenna assembly, electronics, and the Probe spin-eject device.

High data rate communication with Earth will be via a 4.0-meter diameter Voyager-type High Gain Antenna (HGA), body-fixed and aligned with the Orbiter's -Z axis. An aft-facing (+Z axis) Low Gain Antenna (LGA) and a forward-facing (-Z axis) LGA will be used for two-way communication with the Earth when spacecraft pointing requirements preclude use of the HGA. Redundant 5.6-watt, X-band solid state amplifiers and a new NASA X-band transponder will be used. The spacecraft transmitter frequency will be 8.415 GHz and the spacecraft receiver frequency will be 7.162 GHz. A 5.0-watt, S-band transmitter will be provided for the Radio Science Subsystem (RSS). A redundant 7.0-watt, Ka-Band transmitter will also be available for high-rate telemetry at Saturn encounter.

Most electronics for the spacecraft engineering subsystems and some science electronics will be located in the slightly modified Voyager-type 12-bay toroidal bus.

Three deployable booms will be provided: the HPSP boom, turntable boom, and the magnetometer boom. Specifications on instrument platform and spacecraft pointing accuracy are contained in Volume IV of the Proposal Information Package.

A rotating platform (turntable) on the turntable boom (opposite the HPSP) will provide a greater than 2-pi steradian field of view for fields and particles instruments. The rotation rate will nominally be 1 revolution per minute while orbiting Saturn; 3 revolutions per minute will be possible for limited periods; and 0.1 revolution per minute is planned for much of the cruise to Saturn. Specifications on turntable capabilities are included in Volume IV of the Proposal Information Package.

Part of the Propulsion Module Subsystem (PMS) will be obtained from the Federal Republic of Germany (FRG). The PMS will use a bipropellant (monomethylhydrazine [N_2H_2] and nitrogen tetroxide [N_2O_4]) for the main engine, and a monopropellant (hydrazine) for the reaction control system with four thruster clusters. There will be two bipropellant tanks with total capacity of 4300 kg.

Thermal control of the spacecraft will be accomplished by combinations of electrical heaters, one-watt radioisotope heater units, louvers, thermal blankets, and paints.

Thirty (30) VDC power will be distributed to all user loads. Solid-state switches will be used in the power distribution unit, replacing traditional electromechanical relays and thereby eliminating fuses, providing soft turn-on and current limiting, and enhancing fault protection.

The spacecraft will use programmable computers to control the uplink, downlink, subsystem intercommunication, and sequence execution functions, and to provide command, telemetry, and system fault protection functions to all subsystems. The 1.8 Gb Solid State Recorder will allow the data system to rate-match data input to the downlink to optimize performance. All science instruments and engineering subsystems will use a project-designed standard MIL-STD-1553B bus interface unit to communicate with the spacecraft Command and Data Subsystem.

Magnetic, electromagnetic, and electrostatic cleanliness of the Saturn Orbiter will be maintained and controlled. However, the presence of the radioisotope thermoelectric generators (RTG's) and the radioisotope heater units will result in radioactivity on board the spacecraft. Specifications on spacecraft cleanliness and radiation are included in Volume X of the Proposal Information Package.

C. SATURN ORBITER AND HUYGENS PROBE INSTRUMENT PAYLOADS

1. Introduction

The tentatively selected Saturn Orbiter instrument payload is listed in Table 1; instruments comprising the Huygens Probe payload are listed in Table 2. A brief description of each instrument, its measurement capability, and the chief scientific questions it will address are included as appendices in Volume XIV of the Proposal Information Package.

2. Ion and Neutral Mass Spectrometer (INMS) Facility Instrument

a. Background. The importance of including an INMS in the Saturn Orbiter payload, primarily for the investigation of Titan aeronomy, was recognized by both the Cassini JSWG and participants in the NASA instrument selection process. When no acceptable Principal Investigator/Instrument proposals for this instrument were received in response to AO No. OSSA-1-89, NASA declared the INMS a facility instrument and appointed

Table 1. Cassini Saturn Orbiter Payload

Instrument/Investigation	Investigator	Institution
Imaging Science Subsystem (ISS), Facility	Dr. Carolyn C. Porco, TL	University of Arizona
Titan Radar Mapper (RADAR), Facility	Dr. Charles Elachi, TL	Jet Propulsion Laboratory
Visual and Infrared Mapping Spectrometer (VIMS), Facility	Dr. Robert H. Brown, TL	Jet Propulsion Laboratory
Radio Science Subsystem (RSS), Facility	Dr. Arvydas J. Kliore, TL	Jet Propulsion Laboratory
Ion and Neutral Mass Spectrometer (INMS), Facility	Team To Be Selected per AO OSSA-1-91	
Composite Infrared Spectrometer (CIRS)	Mr. Virgil G. Kunde, PI	Goddard Space Flight Center
Cosmic Dust Analyzer (CDA)	Prof. Dr. Eberhard Grün, PI	Max-Planck-Institut für Kernphysik
Radio and Plasma Wave Science (RPWS)	Dr. Donald A. Gurnett, PI	University of Iowa
Cassini Plasma Spectrometer (CAPS)	Dr. David T. Young, PI	Southwest Research Institute
Ultraviolet Imaging Spectrograph (UVIS)	Dr. Larry W. Esposito, PI	University of Colorado
Magnetospheric Imaging Instrument (MIMI)	Dr. Stamatios M. Krimigis, PI	Johns Hopkins University
Dual Technique Magnetometer (DTMAG)	Dr. David J. Southwood, PI	Imperial College of London

Table 2. Cassini Huygens Probe Payload

Instrument/Investigation	Investigator	Institution
Descent Imager/Spectral Radiometer (DISR)	Dr. Martin G. Tomasko, PI	University of Arizona
Gas Chromatograph/Mass Spectrometer (GCMS)	Dr. Hasso B. Niemann, PI	Goddard Space Flight Center
Doppler Wind Experiment (DWE)	Dr. Michael K. Bird, PI	Universität Bonn
Atmosphere Structure Instrument (ASI)	Prof. Marcello Fulchignoni, PI	Univeritá di Roma
Aerosol Collector Pyrolyzer (ACP)	Dr. Guy M. Israel, PI	Service d'Aéronomie du CNRS
Surface Science Package (SSP)	Dr. John C. Zarnecki, PI	University of Kent

an INMS Instrument Definition Team (IDT). The IDT was charged to recommend an instrument approach to NASA that would meet the INMS measurement requirements and could be developed and accommodated on the Saturn Orbiter spacecraft within the limited financial resources available.

In March 1991, the IDT recommended that a copy of the CRAF Neutral Gas and Ion Mass Spectrometer (NGIMS) instrument, with minor modification, be selected as the INMS facility instrument for the Cassini Saturn Orbiter. NASA has accepted this recommendation, and Dr. Hasso B. Niemann, Principal Investigator for the CRAF NGIMS, will provide the INMS instrument. A brief description of the measurement opportunity and of the INMS instrument is given below; for more detail, see Volume XIV of the Proposal Information Package.

At this time the INMS is tentatively selected for the Saturn Orbiter payload, as is the case for all the Orbiter instruments prior to confirmation. The final decision regarding inclusion of the INMS in the flight payload will be made, in part, on the basis of proposals received in response to this AO.

In the event that the INMS is selected for inclusion in the Saturn Orbiter payload, NASA will form an INMS Facility Instrument Team. This AO invites proposals from individuals to be the Team Leader (TL) or a Team Member (TM) of such a team (see Section III.A). Selection of the Team Leader and Team Members will be made on the basis of proposals received in response to this AO.

Proposers who wish to be the Team Leader or a Team Member of the INMS Facility Instrument Team should submit proposals according to the guidelines given in Sections III.A and VI.B. Proposals should be based on the instrument description given in Volume XIV of the Proposal Information Package; funding limitations preclude changes in INMS design beyond those already specified by the IDT.

After formation of the INMS Facility Instrument Team, the CRAF/Cassini Project, working in conjunction with the team and the INMS instrument manager (H. Niemann), will be responsible for the development of the flight instrument. The Facility Instrument Team, through the instrument manager, will provide for the final design, fabrication, calibration, and integration of the INMS flight instrument. The Facility Instrument Team will also be responsible for investigation design, observation planning, procedure and algorithm development for data reduction, science analysis and interpretation, publication of results, and data archiving.

b. Scientific Objectives. During the Cassini baseline mission the Saturn Orbiter will make approximately 35 passes through Titan's upper atmosphere, reaching minimum altitudes of 950 km and perhaps lower. The opportunity is thus provided for substantial aeronomical investigations utilizing the INMS, which will make direct measurements of the chemical composition and absolute number densities of the neutral gas and low energy positive and negative ions. The measured scale heights of the neutral gases will give the atmospheric temperature profile, expected to be isothermal except at the lowest altitudes penetrated. Detection and identification of the most abundant atmospheric hydrocarbons will help

in understanding Titan's photochemistry and the role of vertical transport of chemical species. Measurements of ion composition will place strong constraints on models of the complex ion chemistry in Titan's atmosphere, which contains percent quantities of methane and acetylene. Correlation of INMS data with results from Huygens Probe and other Saturn Orbiter instruments will permit investigation of atmospheric diffusive separation, energetics and heat balance, and atmospheric escape.

The measurement of ion scale heights in Titan's topside ionosphere will provide clues to plasma temperatures and flow processes. INMS results will also contribute to studies of the interaction between Titan's upper atmosphere and the Saturnian magnetosphere.

The INMS may also contribute to investigations of the Saturnian icy satellites and rings by detecting gases emitted from their surfaces due to charged particle sputtering and meteoroid bombardment. Plasma wakes of the icy satellites may be detectable at times during the 4-year tour of the Saturnian system.

During times when the INMS is pointed appropriately, it should also be capable of measuring the number densities of the major neutral species and low-energy ions in the Saturnian inner magnetosphere. During high-latitude orbits, the INMS could be used to search for and characterize polar wind outflows contributing to the Saturnian magnetospheric plasma.

c. Instrument Description. The INMS is identical, except for minor modifications, to the Neutral Gas and Ion Mass Spectrometer (NGIMS) under development for the CRAF mission. It consists of two ion sources; an electrostatic quadrupole deflector that selects ions from the desired source; a quadrupole mass analyzer; and a detector. Both positive and negative ions are detected. The gas density environment encountered by the mass spectrometer during Titan flyby is nearly optimal for direct sampling by electron impact ionization since no reduction in pressure from the ambient is required. The two ion sources, designated the open source and closed source, are utilized in order to detect the widest range of species. These sources, respectively, allow reactive species to be measured without any gas surface interactions and non-reactive species to be sampled with increased sensitivity.

The mass range of the instrument is from 1-300 amu, but the measurement of neutral atomic and molecular hydrogen is excluded by instrument background, so for the neutrals the mass range of 3-300 amu should be assumed. The temporal and spatial resolution of the measurements are set by the integration time required to obtain statistically significant signals, but cannot be smaller than a single accumulation period, which is expected to be 32 milliseconds. The sensitivity of the instrument is mass dependent, but in general it can be assumed that the lower limit of neutral density that can be detected with a signal/background ratio of one or greater is about 4×10^4 part cm^{-3}.

The instrument's mass scan is controlled by a microprocessor. While initially the entire mass range might be sampled in an exploratory mode, on subsequent approaches to Titan the instrument's capability to select masses of interest might be exploited. The integration time of

0.032 seconds sets the limit of resolution if a single mass were continually sampled. A full mass scan from 3-300 amu would take about 9.6 seconds.

Instrument parameters and anticipated measurement capabilities of the INMS are given in Table 3.

Properties of the ambient ions that pass through the open source can readily be analyzed, since the quadrupole mass analyzer functions as an ion spectrometer. Only minor switching operations are needed to optimize the instrument for ion rather than neutral particle detection. In the ion mode, spectra of those species present in Titan's upper atmosphere will be obtainable over the instrument's 1-300 amu capability. As with the neutral gas measurements, microprocessor control will allow surveys to be made over the entire ion mass range or to lock on species of particular interest. In addition, the instrument can be commanded to measure either positive or negative ion species. The ion sensitivity and dynamic range of the INMS will allow measurements of thermal ions with concentrations from ~0.1 cm^{-3} up to values exceeding the anticipated thousands of ions cm^{-3} maximum ionospheric values. Utilizing the microprocessor-controllable deflector voltages, the INMS may also be configured to measure the energy distributions of incoming ions with energies ranging from ~1 eV to energies exceeding 100 eV at a resolution $\Delta E/E$ ~0.3.

The INMS is to be mounted on one of the Saturn Orbiter science booms. One consequence of this fixed mounting for Titan flybys is potential conflicts in spacecraft pointing requirements between the INMS investigation, the radar mapping investigation, and radio occultation experiments. The INMS requires that the ion source axis be aligned with the spacecraft velocity vector for optimal science return. Although it is anticipated that pointing during several of the Titan flybys will be optimized for INMS science, significant data can also be obtained during those flybys optimized for radar mapping. This issue is discussed in more detail in Volume XIV of the Proposal Information Package.

D. SPECIAL MISSION CONSTRAINTS

Certain constraints are mandated by NASA's commitment to cost efficiency in all of its Mariner Mark II missions. Others arise because the science instruments to be carried by the Saturn Orbiter will be used in investigations lasting over an extended period of time. These instruments will generate extensive and complementary data sets.

The cost constrained nature of the Cassini mission dictates that the number of selected investigators for each investigation must be restricted. This limitation will constrain the number of INMS Facility Instrument Team Members that can be selected on the basis of this AO. It is estimated that approximately six Team Members will be selected.

Table 3. Cassini Ion and Neutral Mass Spectrometer Parameter Summary

Gas Sampling System	(1) Open Source/Molecular Beaming; (2) Closed Source; (3) Thermal and Suprathermal Positive and Negative Ions
Mass Analyzer	Quadrupole Mass Filter
Ion Source	Electron Impact Ionization with Dual Filaments (for both open and closed source). Three selectable electron energies: nominal 15 eV, 25 eV, and 75 eV.
Mass Range	1 to 300 amu nominal
Viewing Angle	Open source approximately ±8 deg; closed source ±90 deg
Scan Modes	(1) Survey: mass scan over entire range in 1/8 or 1 amu steps; (2) Adaptive: 256 selectable mass values
Sensor Sensitivity	2.5×10^{-3} (counts/sec)/(part/cm^3) for neutral gas ion source density (both open and closed source). Maximum ram enhancement in closed source approximately 25 for N_2 at 5.4 km/sec Titan flyby velocity.
Resolution/Cross Talk	10^{-6} for adjacent masses up to 60 amu; greater cross talk for higher masses
Dynamic Range of Detector System	Approximately 10^{11} covered by pulse counting and electrometer current measurement
Data Rate	Approximately 30 samples per second
Ion Flux Sensitivity	10^{-3} (counts/sec)/(ion/cm^2 sec)
Deployment Mechanism	(1) Metal ceramic breakoff cap, pyrotechnically actuated

Special requirements are also created by the long duration of the data-taking phase of the Cassini mission and the complementary character of the data sets that will be obtained by the Saturn Orbiter and Huygens Probe instruments. To meet these requirements, individuals submitting Team Leader proposals must include a plan for:

- Maintenance of raw and reduced data sets during the mission and until final archiving of the data.

- Registration of reduced data sets, using agreed-upon standards, so that the reduced data can be shared among the various science teams and Interdisciplinary Scientists within the project.

- Systematic data archiving, release, and distribution of reduced data records periodically during the project and at the end of the mission.

More information about plans for data collection and management for the Saturn Orbiter portion of the Cassini mission is contained in Volume V (Mission Operations Description) and Volume XI (Science Management Plan Document) of the Proposal Information Package.

No policies for the data rights of investigators or groups of investigators are established by this AO. All policies concerning data rights, data management, data archiving, and data release will be developed by the Program and Project Offices in conjunction with the Cassini PSG.

E. FLIGHT ENVIRONMENT

The planned Cassini mission requires that the instruments survive and remain operable in several distinct environments. Information on these flight environments is provided in Volume X (Spacecraft Environmental Design Requirements) of the Proposal Information Package.

F. MISSION OPERATIONS

The Mariner Mark II Mission Operations System (MOS) will be located at JPL in a dedicated Mission Support Area (MSA). The MM II MOS will consist of the personnel, equipment, and procedures necessary to conduct flight operations for both the CRAF and Cassini missions. The MOS will be developed prior to launch in order to support the development and validation of basic flight sequences and to support spacecraft-to-MOS compatibility tests. The MOS will support spacecraft system test and launch operations phases and will assume spacecraft control at spacecraft delivery to the Eastern Test Range.

The MM II MOS will perform the primary functions of spacecraft command and control, spacecraft data acquisition, science and engineering information processing, and data archiving

and data management. These functions will be performed with the aid of a network of interconnected data processors that are connected as nodes on a local area network.

The CRAF/Cassini Project will provide one Science Operations and Planning Computer (SOPC) workstation and a communication link for each of the Orbiter science investigation teams and one for the Huygens Probe Operations Center. The SOPC will support the following mission related activities:

1. Delivery of advanced planning information from JPL to the investigator team.

2. Construction by the investigator, and transmission to JPL, of instrument-specific command requests.

3. Delivery of raw instrument data and ancillary spacecraft information from JPL to the investigator.

4. Communication of data to and from other investigators.

During mission operations, raw instrument data in "packet" form will be maintained at JPL in the Project data base and will be accessible by the investigators through their SOPC. Each investigator will be responsible for promptly checking and reporting the health of his or her instrument as data become available. Geometric information (spacecraft attitude and trajectory parameters) sufficient to reconstruct instrument pointing will also be available and accessible to the investigator through the SOPC. The reconstruction of these data to obtain locations, instrument pointing directions, etc., will be the investigator's responsibility using Project-provided software. The investigator will also be responsible for maintaining updated data records that are accessible via the SOPC or similar work station to support interdisciplinary science activities.

The investigator will participate in the identification and resolution of science sequence request conflicts. Planning tools and data will be provided by the Project to assist in this process.

Detailed mission planning for Saturn orbital operations will begin 15 months prior to Saturn Orbit Insertion. During orbital operations, spacecraft command sequences will enter the final design and implementation stage approximately 60 days prior to the actual start of sequence execution. A limited late-date update capability will exist.

Science observations performed by the Saturn Orbiter will be accomplished through the execution of stored onboard sequences. Cruise sequences will be of 3 months' duration and Saturn orbit sequences will be of 1 orbit duration, typically 32 days. Stored sequences may be augmented by real-time commands. All real-time commands will be split into two categories: interactive and non-interactive. An interactive command will require mission management director approval for uplink because spacecraft and ground resources must be expended in the ground generation and spacecraft execution of that command. Noninteractive commands are those which do not affect spacecraft resources and they will, therefore, be uplinked routinely.

Details regarding the investigator's responsibilities are given in Section V.H below (Data Records Requirements and Data Analysis) and in Volumes V and XI of the Proposal Information Package.

Definition of the SOPC is the responsibility of the Jet Propulsion Laboratory's Space Flight Operations Center (SFOC), with oversight by the CRAF/Cassini Project. Selected investigators will participate, through the Cassini PSG, in determining the final configuration of the SOPC and in the development of common software and data formats to assist the investigators in meeting their responsibilities for data management and archiving. The CRAF/Cassini Project will support development of the SOPC and common software to the maximum extent possible. The details of software implementation will be established by discussions between Project management and the Cassini PSG. All investigators must be prepared to use the SOPC during prelaunch spacecraft testing as well as during mission operations, and the investigators will be expected to support testing of the SOPC prior to launch.

For the purpose of providing a common basis for the review of proposals, proposers need not consider costs associated with the development of the work stations and the common software and data formats. (The SOPC work station environment is described in Volume V of the Proposal Information Package.) However, they should provide the best possible estimate of all costs for data management requirements (hardware and software) that are unique to their particular investigation and clearly cannot be met by the SOPC alone.

G. PROGRAM MANAGEMENT

The Solar System Exploration Division of the NASA Office of Space Science and Applications has program management responsibility for the Cassini mission. Project management responsibility has been assigned to the Jet Propulsion Laboratory (JPL) in Pasadena, California.

The design, development, and implementation of the Cassini mission will involve the direct interaction of Program and Project Management and the Cassini PSG (see Section III.C).

H. DATA RECORDS REQUIREMENTS AND DATA ANALYSIS

Many of the scientific objectives of the Cassini mission can be realized only by the detailed analysis of simultaneous, complementary data sets obtained from multiple instruments. While some of these analyses will be accomplished during the mission itself, others will require extended study during a data analysis phase that will follow the mission.

To make shared analyses possible, both during and after the mission, the Project will require that raw data, calibration records, and processed data be maintained in an updated/

upgraded form throughout the period of investigation. Specifically, Principal Investigators and Team Leaders must plan to:

- Maintain a continually updated/upgraded record of the "best version" of the data until significant changes in data calibration no longer occur.

- Adopt a standard format, agreed on by the Cassini PSG, for the "best version" of the data that will make the data easily accessible through the established work stations.

- Make updated/upgraded data records available to other investigators during the mission for shared analysis, at times and to an extent determined by the Cassini PSG or by mutual agreement among investigators.

- Prepare a comprehensive set of data records, supported by appropriate documentation, for deposition in a designated archive at a time and in a format that will be agreed upon by the Cassini PSG, and which is consistent with National Space Science Data Center and Planetary Data System standards. (See Volume XI, Science Management Plan Document, of the Proposal Information Package.)

To establish a common basis for the evaluation of proposals, the data analysis period used for budgeting purposes should be compatible with the Saturn Orbiter baseline mission schedule (see Section V.A.) and should not extend beyond a date one year after the Project delivers the last Supplementary Data File (SDF). For the Saturn Orbiter baseline mission, delivery of the last SDF is expected by June 2008 so that proposed analysis must not extend beyond June 30, 2009. It is anticipated that subsequent studies of Cassini data will be supported through competitive Data Analysis programs open to the entire scientific community.

VI. PROPOSAL SUBMISSION INFORMATION

This AO invites proposals from both United States and non-U.S. scientists. In accordance with NASA policy, all investigations by non-U.S. participants will be conducted without any exchange of funds.

In order to provide a firm basis for the comparison of proposals received in response to this AO, the Saturn Orbiter Baseline Mission described in Section V.A above, the INMS Facility Instrument Description (see Section V.C.2 and Volume XIV of the Proposal Information Package), the Science Management Plan Document (Volume XI of the Proposal Information Package), and the Spacecraft Description (Section V.B above) must be used for proposal preparation.

A. PREPROPOSAL ACTIVITIES

1. Notice of Intent

It is requested that a written Notice of Intent to propose be submitted by all prospective proposers. It should arrive at NASA Headquarters on or before June 10, 1991. This Notice must be typewritten in English and should be addressed to:

Mr. Henry C. Brinton
Program Scientist, CRAF/Cassini
Code SL (Ref. AO No. OSSA-1-91)
NASA Headquarters
Washington, DC 20546
U.S.A.

Telephone Number: (202) 453-1597
FTS 453-1597
Telex Number: 89530 NASA WSH

A Notice of Intent is not required, but is requested as an aid in planning the proposal evaluation process.

Non-U.S. participants should send their Notice of Intent to the same address, and should also send a copy to:

International Relations Division
Code XID (Ref. AO No. OSSA-1-91)
NASA Headquarters
Washington, DC 20546
U.S.A.

Telephone Number: (202) 453-8452
Telex Number: 89530 NASA WSH

The Notice of Intent should briefly describe the objectives of the proposed investigation. Proposers should include their names, addresses, telephone numbers, and telex numbers, as well as their sponsoring organizations.

All material provided to NASA through the Notice of Intent is for information only and is not binding on the signatories. Additional information may be obtained from the CRAF/Cassini Program Scientist at the address above.

2. Proposal Information Package

A Proposal Information Package will be sent to all prospective proposers upon receipt of their Notice of Intent and to others upon receipt of a written request. The Proposal Information Package, which is intended to provide background information and specific details for the preparation of a formal proposal, contains the documents listed in Table 4.

Table 4. Proposal Information Package

Volume I	Proposal Preparation Guidelines
Volume II	Cassini Phase A Report (SCI(88)5) plus Addendum
Volume III	Mission Description
Volume IV	Spacecraft Description
Volume V	Mission Operations Description
Volume X	Spacecraft Environmental Design Requirements
Volume XI	Science Management Plan Document
Volume XII	Policies and Requirements for Science Investigations
Volume XIII	Physical Models
Volume XIV	Ion and Neutral Mass Spectrometer Description

Volumes I through XIII above, including Volumes VI through IX (descriptions of the ISS, VIMS, RADAR, and RSS Facility Instruments), constituted the Proposal Information Package for the original Cassini Saturn Orbiter AO No. OSSA-1-89. These volumes have not been updated to reflect changes in the baseline mission and spacecraft made since that time; these changes are, however, described in the appropriate sections of this AO. Volumes VI through IX are not required for this Announcement and will not be included in the Proposal Information Package.

Volumes I, X, XI, and XII of the Proposal Information Package are intended to provide requirements for prospective proposers in the preparation of proposals. The remaining documents provide information to aid in proposal preparation. In case of a conflict between information or requirements outlined in this AO and those in the Proposal Information Package, this AO and its Appendices take precedence.

3. Preproposal Briefing

No Preproposal Briefing will be conducted.

B. FORMAT OF PROPOSALS

1. General Proposal Format

A uniform proposal format will be required from all proposers in order to aid in proposal evaluation and to facilitate comparative analysis. This format, and the required contents, are summarized below. Please note that the two types of proposals invited by this AO (Facility Instrument Team Leader and Team Member) have different content requirements and length limitations.

General information and general proposal requirements are provided as Appendices A and B to this AO. Specific procedures and details for each of the two types of proposals are described in Volume I (Proposal Preparation Guidelines) of the Proposal Information Package. It should be noted, however, that the instructions in Volume I regarding proposal length limitations and number of copies required have been superseded by the instructions in this AO.

Each proposal should be submitted in two (2) separately-bound volumes: Volume 1, Investigation and Technical Plan; and Volume 2, Management and Cost Plan. All documents must be typewritten in English and must be clearly legible. At least one copy of each document should be clear black print on white paper and of a quality suitable for reproduction. Submission of proposal material by facsimile (FAX), electronic media, video tape, floppy disk, etc., is not acceptable.

2. Investigation and Technical Plan (Volume 1)

Volume 1 should consist of the main body of the proposal and any optional appendices. The volume should provide a clear statement of the proposed investigation and how it will address the scientific objectives of the Saturn Orbiter portion of the Cassini mission. The proposal should contain enough background information to be meaningful to a reviewer who is generally familiar with the field, although not necessarily a specialist.

The proposal should also contain the best possible description of the proposer's plans for data processing, management, and archiving, including the use of the remote work stations, if applicable (see Section V.F). Many of the details of these procedures are not established at this time, but the proposal should include as much information as possible concerning the investigator's plans, requirements, and costs, especially those for unique data management requirements (hardware and software) that cannot be accommodated with the work stations.

The title page of Volume 1, for both types of proposals, must state the title(s), names(s), address(es), affiliation(s), and the telephone number(s) of the Team Leader or Team Member, as appropriate. The title page must also contain the authorizing signatures of appropriate officials of participating organizations. In the Preface to Volume 1 the proposer must also include a separate abstract, one page or less in length, describing the proposed investigation. The title page and the abstract page are not included in the page limits specified below. In complying with

page limits, no page should contain more than 50 lines of text, and the type size should not be smaller than 12 characters per inch.

Details on length and other matters are given below for both Team Leader and Team Member proposals. Regardless of proposal type, appendices are limited to a total of ten (10) single-spaced, typewritten pages, without reduction.

For INMS Facility Instrument Team Leader proposals, the main body of the proposal is limited to a maximum of thirty (30) single-spaced, typewritten pages, without reduction, including illustrations. For Team Member proposals, the main body is limited to a maximum of fifteen (15) single-spaced, typewritten pages, without reduction, including illustrations.

Proposals for INMS Team Leader or Team Member must be submitted by individuals only. Proposals by groups of investigators will not be considered. Proposers may identify, and may request support for, specific individuals or support staff whom they consider essential to the conduct of their investigation, but none of these individuals will be eligible for team membership without having submitted an individual proposal.

A proposer who wishes to be considered for Team Leader must provide clear and substantive support for this request in the body of the proposal. Team Leader proposals must also contain a generic or conceptual plan that addresses optimum team size and essential talents required for the team to meet its responsibilities, keeping in mind that cost considerations limit the team to approximately six members. Individuals proposing to be Team Leader will also be considered for Team Member in the event that they are not selected to be Team Leader; if they do not wish to be so considered, they should so state in their proposal. Proposals for participation as a Team Member should, in addition to the scientific investigation proposed, provide information as to specific talents or technical capabilities that the candidate member would bring to the team.

3. Management and Cost Plan (Volume 2)

This volume does not have page limitations.

a. INMS Facility Instrument Team Leader Proposals. For these proposals, Volume 2 should include a Management and Cost Plan based on the candidate Team Leader's best estimate of an optimum team size and the anticipated activity level of each of the members. No consideration need be given to the cost of building the Facility Instrument, but the Management and Cost Plan should reflect such activities as investigation design, instrument calibration requirements, observation planning, algorithm development, data reduction, and data archiving.

Because Team Leader and Team Member proposals will be submitted separately, it will be difficult for prospective Team Leaders to develop a firm estimate of costs for the actual team that will be selected. For the purposes of proposal evaluation, Team Leader proposals should

contain the best possible estimate of costs, based on the proposer's consideration of the number and type of Team Members needed and the level of activity required to carry out team responsibilities. More detailed estimates of the actual cost involved will be developed after selection of the Team Leader and Team Members.

b. INMS Facility Instrument Team Member Proposals. Cost and Management Plans for these proposals may be simplified, within the guidelines of Appendix B, to the minimum length needed to permit evaluation. It is expected that the bulk of costs for these proposals will be related to manpower (e.g., salary and travel for the Investigator and essential support personnel) and to data processing requirements.

4. Certification

All proposals must be signed by an institutional official authorized to certify institutional support and sponsorship of the investigation, as well as concurrence in the management and financial parts of the proposal.

5. Quantity

All proposers must provide twenty (20) copies of the Investigation and Technical Plan (Volume 1) and ten (10) copies of the Management Plan (Volume 2) to NASA. In addition, all proposers requesting NASA financial support must submit ten (10) copies of the Cost Plan (also bound in Volume 2) to NASA.

6. Submittal Address

Proposals must be mailed to the same NASA address as that for the Notice of Intent (see Section VI.A.1).

7. Deadline

Proposals must arrive at NASA Headquarters on or before August 23, 1991, at 4:30 PM Eastern Daylight Time.

8. Notification

NASA will notify the proposers in writing that their proposals have been received. Each proposer should include a self-addressed envelope with the proposal for this purpose. Proposers

not receiving this confirmation within two weeks after transmittal of their proposals to NASA should contact the CRAF/Cassini Program Scientist at the address in Section VI.A.1.

C. PROPOSALS FROM NON-U.S. INSTITUTIONS

Proposals from individuals outside the U.S. should be submitted in English and in the same format as U.S. proposals. Proposers from non-U.S. institutions are not required to submit a Cost Plan; they must, however, submit a Management Plan. Proposers from non-U.S. institutions must have their proposals reviewed and endorsed by the appropriate sponsoring government agency. The endorsed copy of the proposal should be sent to the NASA International Relations Division (for address, see Section VI.A.1) and should arrive before the deadline for receipt of proposals.

The additional required copies of the proposal should be sent directly to the CRAF/Cassini Program Scientist (for address, see Section VI.A.1) and should arrive before the deadline for receipt of proposals. Sponsoring agencies may, in exceptional circumstances, forward advance copies of unendorsed proposals directly to the CRAF/Cassini Program Scientist if review and endorsement are not possible before the specified deadline. In such cases, NASA should be advised when endorsement can be expected.

All other correspondence from proposers at non-U.S. institutions and their sponsoring organizations should be sent to NASA's International Relations Division (for address, see Section VI.A.1).

All proposals from non-U.S. institutions will compete on an equal basis with U.S.-originated proposals, and go through the same review, evaluation, selection, and confirmation process. For those non-U.S. proposals selected, NASA will arrange with the sponsoring agencies for participation on a cooperative (no exchange of funds) basis, in which NASA and the sponsoring agencies will each bear the cost of discharging its separate responsibilities, including travel and subsistence for its own personnel.

VII. PROPOSAL EVALUATION CRITERIA AND SELECTION PROCEDURES

A. EVALUATION CRITERIA

The fundamental aim of the investigation acquisition process is to identify scientific ideas and unique theoretical and analytical capabilities which best suit the overall scientific and cost objectives of the Saturn Orbiter portion of the Cassini mission, as described in this AO. Accordingly, the following criteria, listed in order of descending importance, will be used in evaluating all proposals submitted in response to this AO:

1. The scientific and technological merit of the proposed investigation and its relevance to this specific opportunity and to the established mission plans and objectives.

2. Total cost and management considerations. Total cost will be considered to include not only that proposed for data analysis, but also the impact of the investigation on spacecraft and mission operation costs. Management aspects include demonstrated capability to adhere to sound business practices.

3. The competence and relevant experience of the proposer and any proposed support personnel as an indication of their ability to carry the investigation to a successful conclusion.

4. The technical and cost risk (uncertainty) associated with the investigation.

5. The reputation and interest of the proposer's institution, as measured by the willingness of the institution to provide the necessary support (logistics, facilities, etc.) to ensure that the investigation can be completed satisfactorily.

NASA may desire to select only a portion of the proposer's investigation and may also desire the proposer's participation with other investigators in a joint investigation. In this case, the proposer will be given the opportunity to accept or decline such partial acceptance and/or participation with other investigators.

B. EVALUATION AND SELECTION PROCEDURES

Proposals received in response to this AO will be evaluated in accordance with the provisions of NASA Handbook NHB 8030.6B (Guidelines for Acquisition of Investigations). All proposals will be subjected to a preliminary screening by the NASA Program Office to determine their suitability and responsiveness to the AO. Proposals that are not responsive to the intent of the AO will be handled as correspondence. Those proposals that are responsive to the AO will then be subjected to a preliminary technical, management, and cost assessment.

Following these preliminary actions, the scientific and technical aspects of each proposal will be assessed by a panel composed of individuals from the U.S. and Europe who are scientific and technical peers of the proposers. A contracting organization will be selected by NASA to provide assistance in the peer panel review process. The purpose of this peer evaluation will be to determine the scientific and technical merit of each proposal, expressed in terms of its strengths and weaknesses. Results of the earlier technical and cost evaluation will be available to these reviewers.

After these evaluations, an ad hoc subcommittee of the NASA Space Science and Applications Steering Committee (SSASC) will consider the proposal evaluations, together with additional information regarding management and cost aspects. This subcommittee will then categorize the proposals according to the following definitions:

Category I: Well-conceived and scientifically and technically sound investigations pertinent to the goals of the program and the Announcement's objectives and offered by a competent investigator from an institution capable of supplying the necessary support to ensure that any essential flight hardware or other support can be delivered on time and within budget and that the data can be properly reduced, analyzed, interpreted, and published in a reasonable time.

Category II: Well-conceived and scientifically and technically sound investigations which are recommended for acceptance, but at a lower priority than Category I.

Category III: Scientifically and technically sound investigations which require further development. (Only applicable to proposals which include development of flight hardware; therefore not applicable to this AO.)

Category IV: Proposed investigations which are recommended for rejection for this particular opportunity, regardless of the reason.

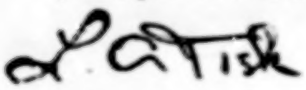
The NASA procedure will be followed in evaluating and selecting the INMS Facility Instrument Team. This procedure and the selections themselves, however, will be closely coordinated with ESA.

Following the evaluations described above, the NASA Program Office (Solar System Exploration Division) will develop a selection recommendation. This recommendation, and all peer review and categorization materials on all the proposals, will be submitted to the SSASC for review. Selections will be made by the Associate Administrator for Space Science and Applications after considering the recommendations of that Committee. These selections will be final; no Accommodation Phase or Science Confirmation Review is planned for these investigations.

VIII. CONCLUSION

The Cassini mission is the first purely planetary exploration endeavor undertaken jointly by NASA and ESA. The combination of the Saturn Orbiter with the Huygens Probe provides the opportunity for an indepth, second phase exploration of Saturn and Titan, as well as Saturn's retinue of rings and other satellites. The data to be obtained will significantly advance our

knowledge of the solar system and its formation and evolutionary processes. I invite you to participate in this important and exciting program.



L. A. Fisk
Associate Administrator for
Space Science and Applications

Enclosures:
1. Appendix A: General Instructions and Provisions
2. Appendix B: Guidelines for Proposal Preparation
3. Appendix C: List of Abbreviations

APPENDIX A
GENERAL INSTRUCTIONS AND PROVISIONS

I. INSTRUMENTATION AND/OR GROUND EQUIPMENT

By submitting a proposal, the investigator and institution agree that NASA has the option to accept all or part of the offeror's plan to provide the instrumentation or ground support equipment required for the investigation, or NASA may furnish or obtain such instrumentation or equipment from any other source as determined by the selecting official. In addition, NASA reserves the right to require use, by the selected investigator, of Government instrumentation or property that subsequently becomes available, with or without modification, that will meet the investigative objectives.

II. TENTATIVE SELECTIONS, PHASED DEVELOPMENT, PARTIAL SELECTIONS, AND PARTICIPATION WITH OTHERS

By submitting a proposal, the investigator and the organization agree that NASA has the option to make a tentative selection pending a successful feasibility or definition effort. NASA has the option to contract in phases for a proposed experiment, and to discontinue the investigative effort at the completion of any phase. The investigator should also understand that NASA may desire to select only a portion of the proposed investigation and/or that NASA may desire the individual's participation with other investigators in a joint investigation, in which case the investigator will be given the opportunity to accept or decline such partial acceptance or participation with other investigators prior to a NASA selection. Where participation with other investigators as a team is agreed to, one of the team members will normally be designated as its team leader or contact point.

III. SELECTION WITHOUT DISCUSSION

The Government reserves the right to reject any or all proposals received in response to this Announcement when such action shall be considered in the best interest of the Government. Notice is also given of the possibility that any selection may be made without discussion (other than discussions conducted for the purpose of minor clarification). It is, therefore, emphasized that all proposals should be submitted initially on the most favorable terms that the offeror can submit.

IV. NON-U.S. PROPOSALS

Guidelines for non-U.S. responses to this Announcement of Opportunity are presented in Appendix B, Section II, paragraph 3.

V. TREATMENT OF PROPOSAL DATA

It is NASA policy to use information contained in proposals and quotations for evaluation purposes only. While this policy does not require that the proposal or quotation bear a restrictive notice, offerors or quoters should, in order to maximize protection of trade secrets or other information that is commercial or financial and confidential or privileged, place the following notice on the title page of the proposal or quotation and specify the information, subject to the notice by inserting appropriate identification, such as page numbers, in the notice. In any event, information (data) contained in proposals and quotations will be protected to the extent permitted by law, but NASA assumes no liability for use and disclosure of information not made subject to the notice.

RESTRICTION ON USE AND DISCLOSURE OF
PROPOSAL AND QUOTATION INFORMATION (DATA)

> The information (data) contained in (insert page numbers or other identification) of this proposal or quotation constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed for other than evaluation purposes; provided, however, that in the event a contract is awarded on the basis of this proposal or quotation the Government shall have the right to use and disclose this information (data) to the extent provided in the contract. This restriction does not limit the Government's right to use or disclose this information (data) if obtained from another source without restriction.

VI. STATUS OF COST PROPOSALS (PROPOSALS REQUESTING NASA SUPPORT)

The investigator's institution agrees that the cost proposal submitted in response to this Announcement is for proposal evaluation and selection purposes, and that, following selection and during negotiations leading to a definitive contract, the institution will be required to resubmit or execute Standard Form (SF) Form 1411 "Contract Pricing Proposal Cover Sheet" and all certifications and representations required by law and regulation.

VII. LATE PROPOSALS

The Government reserves the right to consider proposals or modifications thereof received after the date indicated for such purpose, should such action be in the interest of the Government.

VIII. SOURCE OF SPACE INVESTIGATIONS

Investigators are advised that candidate investigations for space missions can come from many sources. These sources include those selected through the AO, those generated by NASA in-house research and development, and those derived from contracts and other agreements between NASA and external entities.

IX. DISCLOSURE OF PROPOSALS OUTSIDE GOVERNMENT

NASA may find it necessary to obtain proposal evaluation assistance outside the Government. Where NASA determines it is necessary to disclose a proposal outside the Government for evaluation purposes, arrangements will be made with the evaluator for appropriate handling of the proposal information. Therefore, by submitting a proposal, the investigator and institution agree that NASA may have the proposal evaluated outside the Government. If the investigator or institution desire to preclude NASA from using an outside evaluation, the investigator or institution should so indicate on the cover. However, notice is given that if NASA is precluded from using outside evaluation, it may be unable to consider the proposal.

X. EQUAL OPPORTUNITY (U.S. PROPOSALS ONLY)

By submitting a proposal, the investigator and institution agree to accept the following clause in any resulting contract:

EQUAL OPPORTUNITY

During the performance of this contract, the Contractor agrees as follows:

1. The Contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

2. The Contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to (a) employment; (b) upgrading; (c) demotion; (d) transfer; (e) recruitment or recruitment advertising; (f) layoff or termination; (g) rates of pay or other forms of compensation; and (h) selection for training, including apprenticeship.

3. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, the notices to be provided by the Contracting Officer that explain this clause.

4. The Contractor shall, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

5. The Contractor shall send to each labor union or representative of workers with which it has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Contracting Officer, advising the labor union or workers' representative of the Contractor's commitments under this clause, and post copies of the notice in conspicuous places available to employees and applicants for employment.

6. The Contractor shall comply with Executive Order 11246, as amended, and the rules, regulations, and orders of the Secretary of Labor.

7. The Contractor shall furnish to the contracting agency all information required by Executive Order 11246, as amended, and by the rules, regulations, and orders of the Secretary of Labor. Standard Form 100 (EEO-1), or any successor form, is the prescribed form to be filed within 30 days following the award, unless filed within 12 months preceding the date of award.

8. The Contractor shall permit access to its books, records, and accounts by the contracting agency or the Office of Federal Contract Compliance Programs (OFCCP) for the purposes of investigation to ascertain the Contractor's compliance with the applicable rules, regulations, and orders.

9. If the OFCCP determines that the Contractor is not in compliance with this clause or any rule, regulation, or order of the Secretary of Labor, the contract may be cancelled, terminated, or suspended in whole or in part, and the Contractor may be declared ineligible for further Government contracts, under the procedures authorized in Executive Order 11246, as amended. In addition, sanctions may be imposed and remedies invoked against the Contractor as provided in Executive Order 11246, as amended, and by the rules, regulations, and orders of the Secretary of Labor, or as otherwise provided by law.

10. The Contractor shall include the terms and conditions of subparagraph 1 through 9 of this clause in every subcontract or purchase order that is not exempted by the rules, regulations, or orders of the Secretary of Labor issued under Executive Order 11246, as amended, so that these terms and conditions will be binding upon each subcontractor or vendor.

11. The Contractor shall take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing these terms and conditions, including sanctions for noncompliance; provided, that if the Contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of direction, the Contractor may request the U.S. to enter into the litigation to protect the interests of the U.S.

XI. PATENT RIGHTS

1. For any contract resulting from this solicitation awarded to other than a small business firm or nonprofit organization, the clause at NFS 18-52.227-70, "New Technology," shall apply. Such contractors may, in advance of contract, request waiver of rights as set forth in the provision at NFS 18-52.227-73, "Requests for Waiver of Rights to Inventions."

2. For any contract resulting from this solicitation awarded to a small business firm or nonprofit organization, the clause at FAR 522.227-11, "Patent Rights--Retention by the Contractor (Short Form)" (as modified by NFS 18-52.227-11), and the clause at NFS 18-52.227-73, "Patent Rights Clause for Subcontracts," shall apply.

APPENDIX B
GUIDELINES FOR PROPOSAL PREPARATION

The following guidelines apply to the preparation of proposals by potential investigators in response to an AO. The material presented is merely a guide for the prospective proposer, and it is not intended to be all encompassing or directly applicable to the various types of proposals that can be submitted. The proposer should, however, provide information relative to those items applicable or as otherwise required by the AO. Specific procedures and details for each of the two types of proposals invited by this AO are described in Volume I of the Proposal Information Package.

A. COVER LETTER

A letter or cover page should be forwarded with the proposal. It should be signed by the investigator and an official by title of the investigator's organization who is authorized to commit the organization that is responsible for the proposal and its contents.

B. TABLE OF CONTENTS

The proposal should contain a table of contents.

C. IDENTIFYING INFORMATION

The proposal should contain a short descriptive title for the investigation, the names of all investigators, and the name of the organization or institution. The full name of the Principal Investigator, address with zip code, and telephone number should be included.

I. INVESTIGATION AND TECHNICAL PLAN

A. INVESTIGATION AND TECHNICAL PLAN

The investigation and technical plan generally will contain the following:

1. Summary. A simple, concise statement about the investigation, its conduct, and the anticipated results.

2. Objectives and Significant Aspects. A brief definition of the objectives, their value, and their relationships to past, current, and future efforts. The history and

basis for the proposal and a demonstration of the need for such an investigation. A statement of present development in the discipline field.

3. Investigation Approach.

a. Fully describe the concept of the investigation.
b. Detail the method and procedures for carrying out the investigation.

B. INSTRUMENTATION

This section should describe all information necessary to plan for experiment development, integration, ground operations, and flight operations. This section must be complete in itself without the need to request additional data. Failure to furnish complete data may preclude evaluation of the proposal.

1. Instrument Description. (Not applicable to this Announcement.) This section should fully describe the instrumentation and indicate items that are proposed to be developed, as well as any existing instrumentation. Performance characteristics should be related to the experiment objectives as stated in the proposal.

2. Instrument Integration. (Not applicable to this Announcement.) This section should describe all parameters of the instrument pertinent to the accommodation of the instrument in the spacecraft. These include, but are not limited to: volumetric envelope, weight, power requirements, thermal requirements, telemetry requirements, sensitivity to or generation of contamination (e.g., electromagnetic interference, gaseous effluents), data processing requirements.

3. Ground Operations. This section should identify any special requirements for prelaunch or postlaunch ground operations support for the proposed investigation.

4. Flight Operations. This section should identify any requirements for flight operations support, including mission planning. Operational constraints, viewing requirements, and pointing requirements should also be identified. Describe any special communications, tracking, or near real-time ground support requirements and indicate any special equipment or skills required of ground personnel.

C. DATA REDUCTION AND ANALYSIS

A discussion of the data reduction and analysis plan including, insofar as possible, the method and format. A section of the plan should include a schedule for the submission of reduced data to the receiving point as specified in this AO.

II. MANAGEMENT AND COST PLAN

A. MANAGEMENT PLAN

The management plan should summarize the management approach and the facilities and equipment required. Additional guidelines applicable to non-U.S. proposers are contained herein.

1. Management

a. The management plan sets forth the investigator's approach for managing the work, the recognition of essential management functions, and the overall integration of these functions.

b. The management plan gives insight into the organization proposed for the work, including the internal operations and lines of authority with delegations, together with internal interfaces and relationships with NASA, major subcontractors, and associated investigators. Likewise, the management plan usually reflects various schedules necessary for the logical and timely pursuit of the work, accompanied by a description of the investigator's work plan and the responsibilities of the support personnel.

c. The management plan should include the following, as applicable:

(1) Availability of supporting personnel in the institution to successfully administer the contract.

(2) Status of development of the instrument, e.g., what additional development is needed. Areas that need further design or in which unknowns are present.

(3) Method by which the investigator proposes to:

(a) Review instrument hardware and software specifications.

(b) Review development progress.

(c) Review design and fabrication changes.

(d) Participate in testing program.

(e) Participate in final checkout and calibration.

(f) Support the flight operations.

(g) Coordinate with other related investigations and support personnel.

(4) Planned participation by small and/or minority business in any subcontracting for investigative support functions.

2. Facilities and Equipment

All major facilities, laboratory equipment, and ground-support equipment (GSE) (including th se of the investigator's proposed contractors and those of NASA and other U.S. Government agencies) essential to the experiment in terms of its system and subsystems are to be indicated, distinguishing insofar as possible between those already in existence and those that will be developed in order to execute the investigation. The outline of new facilities and equipment should also indicate the lead time involved and the planned schedule for construction, modification, and/or acquisition of the facilities.

3. Guidelines for Non-U.S. Participation

The following guidelines are established for non-U.S. responses to NASA's AO and U.S. responses that include non-U.S. participation. These guidelines indicate the appropriate measures to be taken by non-U.S. participants, prospective non-U.S. sponsoring agencies, and NASA leading to the selection of a proposal and execution of appropriate arrangements. They include the following:

a. Where a "Notice of Intent" to propose is requested, prospective non-U.S. participants should write directly to the NASA official designated in the AO and send a copy of this letter to the International Relations Division, Office of External Relations, Mail Code XID, National Aeronautics and Space Administration, Washington, DC 20546, U.S.A.

b. Unless otherwise indicated in the AO, proposals will be submitted in accordance with this Appendix (excluding Cost Plans). Proposals must be typewritten and in English.

c. Non-U.S. proposals and U.S. proposals that include non-U.S. participation, must be endorsed by the respective government agency or funding/sponsoring institution in that country from which the non-U.S. participant is proposing. Such endorsement should indicate:

1) The proposal merits careful consideration by NASA.

2) If the proposal is selected, sufficient funds will be available to undertake the activity envisioned.

d. Proposals in the requested number of copies and letters of endorsement from the non-U.S. governmental agency must be forwarded to NASA in time to arrive before the deadline established for this AO. The endorsed original of the proposal should be sent to:

International Relations Division
Office of External Relations
Mail Code XID (A.O. No. OSSA-1-91)
National Aeronautics and Space Administration
Washington, DC 20546
U.S.A.

The additional copies of the proposal should be forwarded directly to the Program Office specified in the AO.

e. All proposals must be received before the established closing date and time; those received after the closing date will be treated in accordance with NASA's provisions for late proposals. Sponsoring non-U.S. government agencies may, in exceptional situations, forward a proposal directly to the above address if review and endorsement are not possible before the announced closing date. In such cases, NASA's International Relations Division should be advised when a decision on endorsement can be expected.

f. All non-U.S. proposals will undergo the same evaluation and selection process as those originating in the U.S. Non-U.S. proposals and U.S. proposals that include non-U.S. participation must follow all other guidelines and requirements described in this AO.

g. Shortly after the deadline for this AO, NASA's International Relations Division will advise the appropriate sponsoring agency which proposals have been received and when the selection process should be completed. A copy of this acknowledgement will be provided to each proposer.

h. Successful and unsuccessful proposers will be contacted directly by the NASA Program Office coordinating the AO. Copies of these letters will be sent to the sponsoring government agency.

i. Should a non-U.S. proposal or a U.S. proposal with non-U.S. participation be selected, NASA's International Relations Division will arrange with the non-U.S. sponsoring agency for the proposed participation on a no-exchange-of-funds basis, in which NASA and the non-U.S. sponsoring agency will each bear the cost of discharging its respective responsibilities. Depending on the nature and extent of the proposed cooperation, these arrangements may entail:

(1) A letter of notification by NASA.

(2) An exchange of letters between NASA and the sponsoring non-U.S. governmental agency.

(3) A Memorandum of Understanding between NASA and the sponsoring non-U.S. governmental agency.

B. COST PLAN (PROPOSALS REQUESTING NASA SUPPORT)

The cost plan should summarize by Government Fiscal Year (October 1 to September 30) the total investigation cost by major categories of cost as well as by function.

1. The categories of cost should include the following:

a. Direct Labor. List by labor category, with labor-hours and rates for each. Provide actual salaries of all personnel and the percentage of time each individual will devote to the effort.

b. Overhead. Include indirect costs which, because of their incurrence for common or joint objectives, are not readily subject to treatment as a direct cost. Usually this is in the form of a percentage of the direct labor costs.

c. Materials. This should give the total cost of the bill of materials, including estimated cost of each major item. Include lead time of critical items.

d. Subcontracts. List those over $25,000, specify the vendor and the basis for estimated costs. Include any baseline or supporting studies.

e. Special Equipment. Include a list of special equipment with lead and/or development time. Include number of units and types.

f. Travel. List estimated number of trips, destinations, duration, purpose, number of travelers, and anticipated dates.

g. Other Costs. Costs not covered elsewhere.

h. General and Administrative Expense. This includes the expenses of the institution's general and executive offices and other miscellaneous expenses related to the overall business.

i. Fee (if applicable).

2. Separate schedules, in the above format, should be attached to show total cost allocable to the following by Government Fiscal Year:

a. Team Leader or Team Member Costs for Science Support. The science support category includes all efforts associated with overall investigation management; support of the Cassini PSG; the development of calibration requirements (but not calibration itself); the planning for the mission operations/data analysis phase, including necessary prelaunch development of ground software required only for postlaunch activities. This category begins on December 1, 1991, and ends on January 1, 1996 (approximately launch plus 30 days).

b. Hardware Costs. (Not applicable to this Announcement.) The hardware category consists of all efforts, including field support at JPL, associated with the design, fabrication, test, calibration, operation and maintenance of the flight instrument(s) and a suitable complement of spare components (and functional or nonfunctional models such as Engineering Models and Temperature Control Models as required by the Project); the design, development, test, operation, and maintenance of instrument ground support equipment; the design, test, and maintenance of instrument and support equipment software; support to the Project regarding matters related to the integration of the flight instrument with the spacecraft; and the engineering management of the foregoing efforts. This category begins on December 1, 1991, and ends on January 1, 1996.

c. Mission Operations/Data Reduction and Analysis Costs. The mission operations/data analysis phase includes all costs associated with the investigation beginning on January 2, 1996, including support of the PSG, mission operations, computer time, and data

reduction, analysis, and archiving. As with science support, it also includes investigator support of the PSG working groups, but in the period after January 2, 1996, until June 30, 2009.

3. If the effort is sufficiently known and defined, a funding obligation plan should provide the proposed funding requirements of the investigations by annum keyed to the work schedule.

APPENDIX C

LIST OF ABBREVIATIONS

amu	Atomic mass unit
AO	Announcement of Opportunity
AU	Astronomical Unit. Distance from the Sun to the Earth.
COMPLEX	Committee on Planetary and Lunar Exploration
CRAF	Comet Rendezvous Asteroid Flyby
DSN	Deep Space Network
ESA	European Space Agency
eV	Electron Volts
FRG	Federal Republic of Germany
GHz	GigaHertz. A radio frequency in billions of cycles per second.
GSE	Ground Support Equipment
HGA	High Gain Antenna
HPSP	High Precision Scan Platform
IDT	Instrument Development Team. For Facility Instruments.
INMS	Ion and Neutral Mass Spectrometer. A Facility Instrument.
ISS	Imaging Science Subsystem. A Facility Instrument.
JPL	The Jet Propulsion Laboratory, Pasadena, CA.
JSWG	Joint Science Working Group
JWG	Joint Working Group
kbps	Kilobits per second. A data transmission rate.
LGA	Low Gain Antenna
Mb	Megabits
MM II	Mariner Mark II
MOS	Mission Operations System
MSA	Mission Support Area
NASA	National Aeronautics and Space Administration
NGIMS	Neutral Gas and Ion Mass Spectrometer. A CRAF PI Instrument.

PI	Principal Investigator on a PI/Instrument Investigation
PMS	Propulsion Module Subsystem
PS	Participating Scientist
PSG	Project Science Group
RADAR	Titan Radar Mapper. A Facility Instrument.
R_J	Radius of Jupiter
R_S	Radius of Saturn
RSS	Radio Science Subsystem. A Facility Instrument.
RTG	Radioisotope Thermoelectric Generator
SDF	Supplementary Data File
SED	Saturn Electrostatic Discharges
SFOC	Space Flight Operations Center. A JPL Facility.
SKR	Saturn Kilometric Radiation
SOI	Saturn Orbit Insertion
SOPC	Science Operations and Planning Computer
SPC	Science Programme Committee of ESA
SSASC	Space Science and Applications Steering Committee of NASA
SSEC	Solar System Exploration Committee of NASA
SSR	Solid State Recorder
TL	Team Leader of a Facility Instrument Team
TM	Team Member of a Facility Instrument Team
VDC	Direct Current (DC) Volts
VIMS	Visual and Infrared Mapping Spectrometer. A Facility Instrument.

* U.S. G.P.O.:1991-282-282:40013

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